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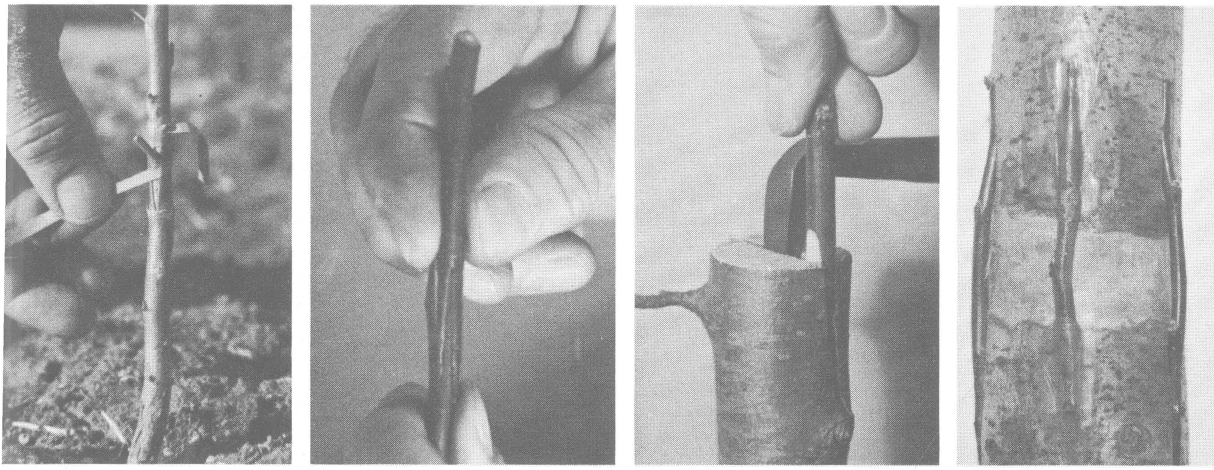

FRUIT TREE PROPAGATION

COOPERATIVE EXTENSION SERVICE
THE OHIO STATE UNIVERSITY

Fruit Tree Propagation

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DEFINITION OF TERMS

BUDDING is a type of grafting. It consists of inserting a single leaf bud, the scion, with or without attached bark and wood piece, into the stock by specific techniques. T-budding, sometimes called shield budding, is done in the latter part of the growing season from late June into September. Chip budding may be done in the spring before growth starts or during the growing season when active growth temporarily ceases.

BUDLING is used to identify the plant resulting from the first year's growth after budding.

BUDSTICK is current season's shoot growth from which single buds are removed for budding.

CALLUS is the mass of regenerating cells, called parenchyma cells developing from and around wounded tissue. The union between a rootstock and scion results from the interlocking of the cells from both parts. Likewise, roots usually arise first from the callus tissue at the basal ends of cuttings.

CAMBIUM LAYER refers to a single layer of cells between the wood and bark tissues which surrounds all woody portions of a tree. This layer of cells, through cell division, produces two sets of cells that make up the growing tissues on both sides of it. On the outside, the new cells form phloem. On the inner side, the wood or xylem tissues are formed. The phloem tissues eventually make up the layers of bark. The cambium is thus the source of all growth in diameter of the woody stem. In propagating trees, the cambium of the scion must line up with the cambium of the stock as perfectly as possible if a good union is to result.

CLONE (or clon) is a horticultural term denoting a specific cultivar propagated asexually or vegetatively. Specific rootstocks used in fruit tree propagation so propagated are called clonal rootstocks.

CUTTINGS are sections of plant stems, leaves, buds or roots which root and grow after proper insertion in sand, soil, or other suitable media.

CULTIVAR is the term now used in place of "variety" which was common in horticultural literature for many years. Cultivar, used to designate horticultural varieties throughout the world, was adopted by the International Code of Nomenclature for Cultivated Plants in 1961. The term is widely used in Europe and is now being used generally in the United States. Throughout this bulletin the term, cultivar, replaces the former term variety.

DORMANCY (SEED) is a term referring to the failure of a seed to germinate even though ideal conditions exist. In such cases, pregermination treatment such as cold stratification is necessary to break dormancy. Dormant plants or buds are those not actively growing but can resume growth with favorable environmental conditions.

GRAFTING is a term referring to various techniques of inserting a section of stem with leaf buds (the scion) into the stock. Since dormant scions are used, grafting is done in early spring, usually before growth begins.

INTERSTEM or **INTERSTOCK** refers to a section of trunk or the basic framework which is introduced between the rootstock and the scion cultivar. An interstem is chosen for specific vegetative characteristics or for the effect it may have upon tree size. Interstems may be used to develop desirable framework characteristics, winter hardiness or disease resistance, or to make possible the joining of two cultivars which are incompatible if grafted directly. Thus, such trees consist of three distinct parts: the rootstock, the interstem and the scion cultivar.

MOUND LAYERING is a method of vegetative propagation. An individual plant may be layered, or plants may be lined out in rows for layering. First, the top of each plant is cut back. As shoots develop from the basal part of the stem, soil or other rooting medium is mounded (hilled) over the base of the shoots, without completely covering the new growth. Plant species and cultivars successfully layered form roots on the portion of the stem (shoot) below the soil surface. The rooted shoots are removed later and used as rootstocks for budding and grafting.

ROOTSTOCK is that part of a tree which becomes the root system of a grafted or budded tree.

SCION denotes a short piece of twig or a bud with attached section of bark inserted into the stock.

SEEDLING refers to a plant grown from a seed.

STOCK identifies a plant or plant root system to which a scion cultivar is grafted or budded.

STOOL or **STOOL BED** designates a plant or group of plants of a specific clone or rootstock to be multiplied by mound layering.

SUCKER or **ROOT SUCKER** refers to shoot growth arising from the crown or roots of a tree, generally below the graft union at or just below the soil surface.

TOP WORKING is the practice of changing the top of a tree from one cultivar to another through the use of budding or grafting methods.

VARIETY is the term that was used for many years to denote a cultivated variety of plant. It is being replaced by the term "cultivar" in horticultural literature (see cultivar).

WATERSPOUT indicates a vigorously growing unbranched shoot of the current season. It generally grows vertically and may arise from a primary scaffold or smaller branch, often adjacent to a pruning wound.

Fruit Tree Propagation

The search for improved rootstocks, better cultivars and more successful techniques for reproducing fruit trees is a constant effort. Changes are continually taking place in propagation techniques and the choice of cultivars and rootstocks for specific purposes. Size controlling rootstocks and hardy, productive, high quality fruit cultivars are important to commercial plant propagators, modern fruit producers and amateur horticulturists It is important for the commercial propagator to keep abreast of any changes, if the best planting stock is to be available for a modern fruit industry.

Successful fruit production depends on correct choice of suitable cultivars for the purpose or market intended. Likewise, the desirability, uniformity, precocity and consistent productivity of a particular rootstock are of interest. All of these considerations are involved in fruit tree propagation.

Plant propagation techniques directly benefit modern fruit producers. Using appropriate techniques, it is possible to combine new and promising cultivars with size controlling or other specialized rootstocks. Such combinations are often not available commercially. In addition to producing trees for new plantings, a fruit grower can convert established plantings of a certain cultivar to a more desirable cultivar by use of propagation methods such as topworking.

Budding and grafting are the most common methods of propagating desired cultivars of tree fruits. With some rootstocks, use of other vegetative methods such as rooting of cuttings (stem, leaf or root), layering, or root suckers may be considered. Some rootstocks are produced directly from seed, but the propagator must be aware that use of seedlings can result in some variability in individual tree characteristics. Such variation results from random pollination and subsequent seed fertilization.

The amateur horticulturist willing to try a variety of fruit tree propagation methods can add interest to growing fruit at home. For example, trees can be converted from one cultivar to another or combination trees of several cultivars can be made by using appropriate grafting techniques. Such activities provide a challenge and personal satisfaction when successful.

When propagating fruit trees, it is important for the propagator to understand several fundamental scientific concepts.

Cultivars of fruit do not produce plants true to type from seed. Thus if seeds of a Jonathan apple are planted, each resulting seedling will have characteristics differing to some extent from the parent. It is possible that few or none will produce fruit even resembling Jonathan. Thus, fruit cultivars must be reproduced by asexual or vegetative means and not from seed if original characteristics are to be maintained. Seeds of some Prunus species may produce trees somewhat similar to the parent plant, yet none will exactly duplicate the seed source characteristics.

Modern orchards are planted with cultivars grafted onto specific rootstocks. Since the rootstock is different from the cultivar, use of root suckers from these trees will serve only as a source of rootstock, with characteristics differing from the cultivar grown above ground for its fruit.

Those considering fruit tree propagation as a business or hobby are urged to consider not only the direct costs but also the labor required in the care of trees after propagation. Special care in providing adequate nutrition, supplemental watering, weed control, proper digging, handling and storing are essential to success. Specific time, labor, planting space limitations and management requirements must be considered in planning the propagation of large numbers of trees.

In the following pages, the reader will find detailed information on the propagation of seedling and clonal rootstocks. Suggested budding and grafting procedures used in propagating fruit tree cultivars are also described.

Rootstock Considerations

Rootstocks for propagation of tree fruit may be purchased from specialized nurseries or propagators. However, the grower may wish to produce his own rootstocks from a selected source of seed or from clonal stocks.

Seedling rootstocks are produced from the seed of a given species or cultivar. Rootstocks are also produced from certain clones by vegetative means such as mound layering. The East Malling and Malling-Merton clonal selections used for controlling the size of apple trees are propagated vegetatively. Some clonal rootstocks can be propagated by cuttings.

COMPATIBILITY

A stock and scion are considered fully compatible when a complete and satisfactory union of the two plant parts results following budding or grafting. Not only must the union be complete, but the tree must grow and perform satisfactorily for the normal useful life of a tree, if the combination is to be commercially valuable.

Incompatibility is defined as the failure of a stock and scion to develop complete union.

Likewise, the failure of grafted trees to perform satisfactorily may be due to a degree of incompatibility. Thus, incompatibility may appear as a complete lack of union between stock and scion, or as partial incompatibility, resulting in poor performance of the tree.

There is no way to adequately predict compatibility of untried stock-scion combinations. The compatibility of any new stock-scion combination is still largely determined by trial and careful observation.

Likewise, it is thought that closely related species like the peach *(Prunus persica)* and European plum *(Prunus domestica)* should be compatible. However, compatibility cannot be taken for granted. Stock-scion compatibilities are discussed in the various sections of this bulletin concerned with specific fruits.

SELECTION OF SEEDLING ROOTSTOCKS

Apples—Seeds from the cultivars Delicious, Rome Beauty, Golden Delicious, and Jonathan have given the best results in producing seedlings for apple cultivar propagation. The triploid cultivars such as Baldwin, Rhode Island Greening, Gravenstein, Stayman, and Turley are unsatisfactory for producing seedlings, partially because of poor seed germination.

Pears—Seed of the Bartlett cultivar is most widely used for producing seedlings on which standard pear cultivars are propagated. Winter Nelis and Beurre Hardy are also satisfactory seed sources.

Certain oriental pear species *(Pyrus calleryana, P. serotina* and *P. ussuriensis)* show greater resistance to fire blight than do cultivars of common pears. Some have been tried as blight-resistant rootstocks, but most have failed to perform satisfactorily.

Quinces—Seed of the common cultivars of quince are used as rootstocks for propagating this fruit. Clonally propagated Angers Quince East Malling Type A may also be used for propagating cultivars.

Apricots—Seedlings from seed of common cultivars of apricots are preferred. Seedlings of the Myrobalan plum *(Prunus cerasifera)* may also be used and produce satisfactory trees under most conditions.

Cherries—Two rootstocks are in common use for propagating cherry trees. Mazzard, or wild sweet cherry *(Prunus avium)*, is the most widely used and best adapted rootstock for sweet cherry cultivars. Mahaleb cherry *(Prunus mahaleb)* is the preferred rootstock for red tart cultivars, such as Montmorency.

Advantages of Mazzard as a rootstock lie in its ability to produce larger, long-lived trees and its compatability with a wide variety of sweet cherry cultivars. Mazzard roots will tolerate slightly less well-drained soils, but will perform best on soils with good internal drainage.

Mahaleb rootstocks are more winter hardy and more drought resistant than Mazzard but do require a well-drained soil. Cultivars on this stock tend to come into bearing earlier than on Mazzard. Selection of rootstocks, however, cannot replace planting on well-drained sites.

Seedling rootstocks from the crosses of Mazzard × Mahaleb (M × M) are currently being evaluated with the objective of obtaining combinations of desirable characteristics from both species. Once the best of these are selected, limited clonally propagated stock of some of the M × M rootstocks should be available from commercial propagators.

Virus diseases such as cherry yellows and necrotic ring spot are present in most trees of both the Mahaleb and Mazzard species. These diseases are among the viruses that can be transmitted through the seed. It is important to obtain seed from trees that are known to be free of the major virus diseases. Seed of virus-infected trees will produce many virus-infected seedlings. When used as rootstocks, these in turn infect the cultivar budded on them, reducing vigor and productivity.

Peaches and Nectarines—Seed of common peach cultivars such as Redhaven, Halehaven, Elberta and Belle of Georgia produce satisfactory seedlings on which to bud these fruits. In nursery propagation, seed of the Lovell peach, a California cling, has been widely used for commercial orchards. Certain selections of red-leaved peach cultivars are available from propagators. If buds do not unite with these rootstocks, the stock growth can be readily distinguished from growth of a cultivar, since shoots from the rootstock will have red leaves. Rutgers Red Leaf is probably the most common of these selections. Some selections of the red-leaved peaches may produce trees that are weak and small due to incompatibilities between the rootstock and the scion cultivar.

More cold hardy peach rootstocks such as Siberian C, Harrow Blood and Bailey also are presently being considered. Of these, Siberian C is currently the most readily available and frequently used. Characteristics of selected peach rootstocks are outlined in Table 1, page 6.

Plums and Prunes—The most widely used rootstock is the Myrobalan or cherry plum *(Prunus cerasifera)* Seedling trees in California and other states constitute the largest source of Myrobalan seed supply. Seed from domestic cultivars such as Stanley, Italian Prune, Green Gage and French Prune can be used but are much less satisfactory than Myrobalan.

Myrobalan seedlings frequently show a leaf spotting called "chlorotic fleck." Affected seedlings are smaller than normal ones, as are trees budded on them, and should not be used in propagation of any plum cultivars. The Stanley cultivar is particularly susceptible to this difficulty and develops a constriction at the bud union when budded on infected seedlings of Myrobalan. Trees so affected are weak and short-lived. The causal factor, which may be a virus, is carried in the seed and transmitted to susceptible cultivars propagated on that stock.

There are certain strains of Myrobalan plum that are now considered free from virus.

Whenever possible, rootstock material known to be free from virus should be obtained for propagation.

PRODUCTION OF SEEDLINGS

Seed for the production of rootstocks should be taken from ripe fruit or obtained from a reliable source. The possibility of virus diseases or incompatibility between fruit cultivars and rootstock selections make it necessary for the fruit tree propagator to obtain seed from known healthy trees or from a reliable seed supplier.

Four conditions important in producing desirable fruit tree seedlings are: (1) seed properly conditioned before planting, (2) a well-drained planting site with soil of good tilth and fertility, (3) seedling rows kept weed-free throughout the growing season and (4) supplemental irrigation when required.

Conditioning of Seed

Seed of tree fruit will rarely germinate when planted directly from the mature fruit. It is first necessary for the seed to complete a period of "after-ripening." During this period a series of chemical changes and embryo development essential to germination takes place within the seed.

These changes can be completed only if seed are stored between 33° and 45° F under moist conditions for a certain length of time. Length of period varies with tree species, as shown in Table 2 (page 7). Freezing of seed to break the seed coat or pit is unnecessary. Freezing may, in fact, be injurious to some seed.

Fresh seed from mature fruit may be cleaned and planted immediately, especially in late summer or early

Table 1:—Characteristics of Selected Peach Rootstocks

Rootstock	Relative Rootstock Hardiness	Favorable Characteristics	Unfavorable Characteristics	Remarks
Bailey	Cold hardy	Uniform plants in nursery; good scion compatability.	Heavy root sucker production; susceptible to powdery mildew.	Does not increase scion vigor; no effect on tree size; adapted to fall planting.
Elberta	Cold tender	Good scion compatability.	Poor seed germination; lacks uniformity in nursery; susceptible to root knot nematodes.	Increases vigor of scion cultivar.
Halford	Medium cold tender	Adapted to fall planting; easily grown and handled in nursery; good scion compatability.	Susceptible to root knot nematodes.	Increases vigor of scion cultivar.
Harrow Blood	Medium hardy	Good scion compatability; good root system development.	Promotes late season defoliation; lacks uniformity and difficult to handle in nursery; susceptible to root knot nematodes.	Reduces tree size only slightly; not adapted to fall planting; may have tolerance to root lesion nematodes.
Lovell	Medium cold tender	Very uniform in the nursery; good scion compatibility; good root system development.	Susceptible to nematodes.	Increases vigor of scion cultivar.
Nemaguard	Cold tender	Resistant to root knot nematodes; uniform in nursery.	May delay scion hardening in fall.	Increases scion vigor.
Rutgers Red Leaf	Medium cold tender	Easily grown and handled in nursery; easy to identify.	May be incompatible with some cultivars; susceptible to nematodes.	Slight but variable reduction in tree size.
Siberian C	Cold hardy	Good scion compatibility; good root system development.	Promotes earlier spring growth and bloom 1-2 days earlier than other rootstocks; susceptible to nematodes.	Promotes early defoliation and scion hardiness; reduces tree size up to 10%; requires well drained soil; advances fruit maturity 1-2 days.

fall (September and October). "After-ripening" processes then take place during the cool temperatures of fall and early winter. Seed are spaced 1 to 3 inches apart in shallow trenches, 3 to 4 inches deep, in the nursery row, and are covered with soil. If the soil type is one that forms a hard crust, it is better, first, to cover seed with a 1-to-2-inch layer of moist peat moss or sawdust, then finish covering with soil.

Before freezing temperatures occur in late fall, the planted rows should be mounded up with additional soil to protect seed over winter. The mound should be 6 to 8 inches high after settling. In early spring, remove mound, leaving a layer of soil 1 to 2 inches thick over the seed through which the sprouts can easily emerge.

Fall planting is preferred for stone fruit seed. Apple, pear, and quince seed may be fall planted, although they are best handled as described in the next paragraph. Ground squirrels and other small animals may burrow in and eat fall-planted seed. To protect the seed, place coarse-screen wire over and around each row of planted seed before mounding up for the winter. Remove screen in the spring before germination takes place.

If fall planting is not possible, artificial conditions that will promote the after-ripening processes must be provided. Seed may be prepared for "after-ripening" in the following manner:

1. Soak dried seed in water for 10 to 12 hours before placing under conditions for "after-ripening."
2. Place soaked or fresh seed in moist peat moss, sawdust, or other moisture-holding material; pack in metal cans, wood boxes, or other containers; cover the container but do not seal air tight.
3. Bury packed containers in the ground over winter, preferably 10 to 12 inches deep in a sheltered area,

   or

   store the packed containers in a refrigerator or a refrigerated room held at a constant temperature near 40° F. Polyethylene bags may be used as the containers for this type of storage. Fold over the tops of the bags, and tie them securely to prevent moisture loss. Air can pass through the polyethylene film. Since this film is transparent, it is possible to inspect the seed periodically without opening the bags. This method of storage is particularly useful with apple, pear, quince and other small seed.

With uniform moisture and cool temperatures, chemical changes take place in the hard shells surrounding seed as well as within the seed themselves. The period of "after-ripening" is definite for each species of fruit (Table 3, page 8). Chemical and physical changes result in the splitting of the outer hard shell and in germ-

Table 2: A Summary of Selected Rootstocks for Fruit Trees

Kind of Fruit	Standard Rootstocks	Special Rootstocks	Remarks
APPLE	Seedlings of Delicious, Rome Beauty, Golden Delicious and Jonathan.	Size controlling clones: M 27, M 9, M 26, M 7, MM 106, MM 111.	Buds or grafts should be inserted 12 to 15 inches from the ground on size controlling rootstocks, permitting deep planting for better anchorage and reduced suckering. M 27 is not yet readily available and has not been adequately evaluated in the U.S. M 27 will probably be used primarily as an interstock, at least initially. M 26 and MM 106 are generally not recommended in Ohio. M 26 is highly susceptible to fireblight. MM 106 is suggested **only** for sites with excellent subsurface soil moisture drainage, due to collar rot susceptibility.
PEAR	Seedlings of Bartlett, Beurre Hardy, and Winter Nelis.	Dwarfing clone; Angers Quince EM Type A preferred, available as rooted cuttings. Other quince stocks may be used.	Since Bartlett and certain other cultivars are incompatible with quince, use an intermediate stock of Old Home between quince root and scion cultivar. Old Home is compatible with both Quince and Bartlett. Old Home may also be used as a blight resistant interstock for Bartlett and other blight susceptible cultivars.
PEACH and NECTARINE	Seedlings of Lovell or domestic cultivars.	Siberian C, Rutgers Red Leaf Dwarfing stocks: Seedlings of Western Sand Cherry; also of Nanking cherry and Beach plum.	Red-leaved clones used in the East make it easy to distinguish between seedling and budded cultivar in nursery rows. Some incompatability has been observed between the Red-leaved peach rootstock and some commercial cultivars.
PLUM and PRUNE	Seedlings of Myrobalan or cherry plum preferred for prune cultivars.	Nematode resistant rootstocks (seedlings): Nemaguard, Rancho Resistant and Okinawa. Available from California for trial use.	Superior selections of Myrobalan should be used when available for all cultivars. Avoid use of seedlings showing symptoms of "chlorotic fleck."
	Japanese cultivars: Mariana plum, in the west.	For American-Japanese hybrids: **Prunus Americana** Seedlings. Dwarfing stock: Western Sand cherry for prune cultivars.	Lovell peach seedlings can be used for plum and prune cultivars, but plum seedlings are preferred.
CHERRY	Red tart cultivars: Mahaleb seedlings. Sweet cultivars: Mazzard seedlings.	Dwarfing stock: Ground cherry **(Prunus fruticosa)**, but not always.	Select seed from trees free from cherry yellows and necrotic ring spot virus diseases. These viruses can be transmitted through seed.
APRICOT	Seedlings of Myrobalan or cherry plum, and of domestic cultivars.		Apricot seedlings preferred in East because of early fruiting habit and resistance to root-knot nematode.

ination of the seed. Seed should be planted just before or as soon as the first sprouting begins. If this is not possible, they may be held in storage at 32° to 34° F for one to three weeks without injury to seed or seedlings.

The outer shell or pit of peach, plum and other stone fruit seed may not always split open at the end of the conditioning period. Such pits may be carefully cracked, the seed removed and viable ones planted. Discard decayed and shriveled seed.

Planting Seed and Care of Seedlings

Fruit tree seed stored out-of-doors over winter should be planted early in the spring. "After-ripening" processes are usually completed sometime in March.

The approximate planting time for seed can be determined by noting when "after-ripening" begins. Thus, if dry Mazzard cherry seed are placed under "after-ripening" conditions between January 1 and 20, the seed should be ready for planting in the nursery row between May 1 and 20. Table 3 gives the length of "after-ripening" periods of seed of several fruit species.

Work up seedbed in a manner similar to that for planting any other farm or garden seed. It is desirable to plow under a winter cover crop of rye or similar grass. In most cases, broadcasting a mixed fertilizer before plowing under the cover crop hastens decay of the crop residue and release of nutrients to plant roots. A suitable application might be 300 pounds per acre of a 12-12-12 analysis fertilizer.

Space tree fruit seeds from 2 to 4 inches apart in shallow trenches and cover with 1 to 2 inches of a peat moss-soil mixture. On light soil where crusting is not likely to occur, the peat moss may be omitted.

Seedlings of most tree fruit species should be large enough for budding to desired cultivars by late July or August or for grafting the following spring. In order to be large enough, they need to be well cared for during the entire growing season. Irrigation during dry periods is essential to produce large seedlings early. If the soil is low in fertility and trees are not making satisfactory growth, an application of nitrogen may be made after

Table 3: After-Ripening Requirements of Certain Fruit Tree Seeds[1,2]

Kind and Cultivar of Seed	Effective Temperature Degrees F.	Best Temperature Degrees F.	Time Required In Days	Remarks
APPLE, Domestic Cultivars **(Malus sylvestris)** Delicious, Rome Beauty, Golden Delicious	40° - 50°	40° - 41°	70 - 80	Seed removed from fruit in cold storage will germinate following 30 days of "after-ripening."
APRICOT, Domestic Cultivars **(Prunus Armeniaca)**	40° - 50°	45°	60 - 70	
CHERRY, Mahaleb **(Prunus mahaleb)**	33° - 50°	41°	90 - 100	Mazzard requires longest "after-ripening" period of stone fruit seed.
Mazzard **(Prunus avium)**	33° - 50°	41°	120 - 140	
PEACH, Domestic Cultivars **(Prunus persica)** Lovell, Siberian C, Harrow Blood, Halford	33° - 50°	45°	120 - 130	Peach seed lose viability during dry storage; seed stored for more than 1 year give low germination.
PEAR, Domestic Cultivars **(Pyrus communis)** Bartlett, Beurre Hardy and Winter Nelis	33° - 41°	40°	60 - 90	Fresh seed taken out of fruit in cold storage will germinate after 30 days of "after-ripening."
OTHER SPECIES				
Sand Cherry **(Prunus besseyi)**	33° - 50°	40°	60 - 90	
Nanking Cherry **(Prunus tomentosa)**	33° - 50°	40°	60 - 75	
Mybrobalan Plum **(Prunus cerasifera)**	40° - 50°	40°	100 - 120	
Ackermann Plum **(Prunus domestica)**	40° - 50°	40°	120 - 130	

1 Adapted from Table 1, Bulletin 773, Propagating Fruit Trees, New York Agricultural Experiment Station.
2 Seed are best stored dry in sealed containers at a cool temperature. In after-ripening seed, keep in mind the approximate planting date in the spring. Determine when the after-ripening period should begin by counting back from this date the minimum number of days required for after-ripening.

the seedlings have made 3 to 4 inches of growth. Ammonium nitrate or urea at 1½ to 2 pounds per 100 feet of row will aid in producing vigorous seedling growth.

Direct sidedress applications of fertilizer uniformly along the tree row 6 to 8 inches away from the trees. Keep fertilizer off foliage to prevent injury to leaves and green bark tissue.

PRODUCTION OF CLONAL ROOTSTOCKS

The most notable clones in fruit tree propagation are the East Malling (EM) and the Malling-Merton (MM) series of rootstocks used for controlling the size of the apple tree. The East Malling series originated about 1917 as selections from the Doucin and Paradise stocks then commonly used in England and Europe for apple tree propagation. The selections were made at the Wye College Fruit Experiment Station at East Malling, England.

The Malling-Merton series originated at the John Innes Horticultural Institute at Merton and the East Malling Station, both in England. The MM stocks resulted from crosses of various East Malling clones and certain cultivars with the Northern Spy. This cross was made to produce rootstocks resistant to the wooly apple aphid. All MM stocks are resistant to this insect pest.

Since 1972, the Malling clonal rootstocks have been designated by Arabic numerals in place of the original Roman numerals. The most common East Malling clones are M 27, M 9, M 7, M 2 and M 13 in the order of their influence in increasing mature tree size. M 13 rootstock produces trees of comparable size to standard seedling rootstock with the same cultivars propagated on them. The most recent addition to the Malling series, M 27, produces the smallest tree, 3 to 5 feet in height.

The common Malling-Merton clones in use are MM 106, MM 104 and MM 111. Trees on MM 106 are similar in size to those on M 7 while MM 104 and MM 111 produce trees similar in size to seedling rootstock. MM 104 is now generally not recommended in replanting or establishing an orchard.

Rooted shoots of M and MM stocks most frequently used for commercial orchards are generally available from commercial propagators. Temporary shortages may occur with certain of the more popular clones and may require ordering one or two years before stock is needed. M 27 is a patented rootstock with rights for propaga-

Table 4: Characteristics of Selected Clonal Apple Rootstocks

Clonal Rootstock	Propagation Method	Growth Effect on Scion Cultivar	Soil Requirements	Favorable Characteristics	Unfavorable Characteristics	Remarks
Malling M 27	Mound Layering	The most dwarfing; less than ¼ size of standard trees.	......	Non-suckering; induces early bearing.	......	Self supporting; probably will have major use as an interstem; not yet evaluated in Ohio.
M 9	Mound Layering	Dwarfing; ¼ to ⅓ size of standard trees.	Fertile, very well drained but with good moisture holding capacity.	Resistant to collar rot; induces early bearing; fruit matures one week earlier than on standard rootstocks; useful as dwarfing interstem.	Brittle roots, tree must be supported, root suckers susceptible to fireblight.	Requires careful management to retain productivity; ideal for high density orchards when trellised or staked.
M 26	Mound Layering, hardwood cuttings, roots well.	Dwarfing; ½ to ⅔ size of standard trees.	Fertile, very well drained; intolerant of wet soil conditions, but not adapted to droughty soils.	Induces early bearing; non-suckering; cold hardy.	May need support, susceptible to fireblight and possibly collar rot.	Virus free stock available; not recommended for Ohio because of severe losses in commercial and research plantings.
M 7 or 7A	Mound Layering, hardwood cuttings, roots well.	Moderately dwarfing; ⅔ to ¾ size of standard trees.	Will tolerate soils containing high clay with high moisture holding capacity; not adapted to poorly drained sites.	Productive; extensively planted; recommended with spur-type cultivars.	Trees may lean in poorly drained soils, requiring support; suckers profusely; moderately susceptible to fireblight; slow to bear with vigorous cultivars such as standard Delicious; somewhat susceptible to collar rot on wet soils.	Trees should be high budded 12-16 inches for deep planting to improve support and reduce suckering. M 7A designates virus free stock.
M 2	Mound Layering, hardwood cuttings, roots well.	Slightly dwarfing; ¾ to ⅞ size of standard trees.	Fertile, well drained.	Vigorous; generally productive with spur-type cultivars.	Trees may lean in poorly drained soils; not adapted for close plantings; cold tender.	Generally being replaced by MM 111, no longer recommended for commercial planting in Ohio.
M 13	Mound Layering, hardwood cuttings, roots profusely.	Standard size; little or no dwarfing.	Fertile, well drained; will tolerate soils with high water table.	Roots near soil surface; well anchored; tolerates poorly drained soils.	Does not induce early bearing; grows poorly in droughty soils; compatibility with many cultivars not determined.	May have some advantage on poorly drained sites; some promise for size control with dwarfing interstem on poorly drained sites; generally not recommended for extensive use in Ohio.
Malling Merton MM 106	Mound Layering, roots well.	Slightly dwarfing; ¾ to ⅞ size of standard trees.	Fertile; very well drained.	Well anchored; does not sucker readily; induces early bearing; resistant to wooly apple aphids.	Highly susceptible to collar rot losses; induces late growth in fall; possibly makes trees more susceptible to late fall cold injury.	Adapted only to sandy soils or other very well drained sites; highly productive with dwarfing interstem on very well drained soils; rarely recommended in Ohio.
MM 111	Mound Layering	Very slight dwarfing; ⅞ to full size of standard trees.	Fertile; well drained.	Well anchored; does not require support; generally non-suckering; more productive than M 2; moderately tolerant of drought; resistant to wooly apple aphids; less susceptible to collar rot than MM 106 or M 7.	Slow to begin bearing; somewhat difficult to root in stool beds.	Not suggested for use with standard cultivars; promising for use with spur type cultivars and as rootstock with dwarfing interstem.

* Standard trees may reach a height of 25 to 30 feet or more.

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Characteristics of Malling and Malling-Merton clonal apple rootstocks and responses under Ohio conditions are summarized in Table 4, page 9.

Fig. 1—Layered East Malling rootstock with well-developed roots. The rooted shoots are pruned off and used for grafting, or are lined out in nursery rows for budding in the summer. New shoots will arise from the base of the mother tree. These will then be mound layered to produce more rooted shoots for cultivar propagation.

Fig. 2—Stool bed of rootstocks with mound of soil and sawdust being removed in preparation for cutting of the rooted shoots.

Certain clonal cultivars of the quince are propagated vegetatively, similar to the above apple clones. Few clonal rootstocks for stone fruits are available, although there is interest in developing such rootstocks for them. Two or three clonally propagated strains of Myrobalan plum are now available as rootstocks for stone fruits. In the near future, preferred selections of the seedling Mazzard x Mahaleb (M x M) crosses should be determined. Once these are selected, clonally propagated stock should become more readily available from commercial propagators.

Mound Layering or Stooling

Certain tree species, cultivars, or clones may be multiplied by mound layering. This is true with the Malling and Malling-Merton apple clones, most quince clones and certain species of plums. A species or clone must have the genetic potential for the rooting of branches or shoots when covered with soil or other suitable rooting medium. Most cultivars of fruit trees do not have this potential.

The procedures described here are especially for layering the M and MM clones of apple rootstocks, but may also apply to other fruit species, cultivars, or clones adapted to this propagation method.

First Season Management

The first step is to establish a stool bed for producing the shoots to be layered. For this it is necessary to get rooted shoots of the desired clone (Fig. 1). These are lined out in a nursery row, spaced 12 to 15 inches apart and set 7 to 9 inches deep, or about half the length of the shoots.

Planting is best done in a trench or furrow. It is gradually filled with soil as the new shoots develop. The trench should be completely filled 30 to 40 days after the beginning of spring growth. Filling in this manner assures good rooting along the stems. The trees are cultivated and permitted to grow unchecked during the first growing season. Each will become a stool or mother plant for the production of future rooted shoots.

Second Season Management

Before growth begins the following spring, all the mother plants are cut back to one inch above the soil level. From two to five new shoots will develop from each mother plant during the second year. When these shoots reach 3 to 5 inches in height, the individual tree or row of trees is ridged up with loose soil or sawdust, enough to cover about two-thirds of the shoots' length. Ridging is repeated as the shoots grow taller, until the ridge is 10 to 12 inches high and some 24 to 30 inches wide. Three ridgings are usually sufficient and should be completed by the end of July. The mounded shoots root readily during the summer and fall. Supplemental watering as needed will encourage more extensive root system development.

Third Season Management

Before growth begins the next spring, the mound is carefully removed, exposing the rooted shoots (Fig. 2). Each shoot is cut off as close as possible to the point at which it originated on the mother plant (Fig. 3). The rooted shoots become the rootstocks for grafting to desired cultivars (Fig. 4), or for lining out in nursery rows to be budded in late summer (Fig. 5). They may also be used to establish new stool beds.

Fig. 3—Rooted layers of rootstocks in the stool bed are being removed for further use in propagating desired cultivars.

After removal of the shoots, the mother plant remains exposed until new shoots have again reached a height of 3 to 5 inches. The mounding procedure is repeated as during the previous summer.

Mother plants in a well managed stool bed remain productive for 15 to 20 years. Layered stems of some clones that have not rooted can be cut off in late winter or early spring and made into hardwood cuttings as described in the next section.

Hardwood Cuttings

Most plants that root when mound layered will also root from cuttings. This is true of most Malling and Malling-Merton apple rootstocks.

Hardwood cuttings are cut from healthy one-year-old dormant branches of from $\frac{3}{16}$ to $\frac{1}{4}$ inch in diameter and from 5 to 6 inches long. Cuttings from the basal end of a shoot will root more readily than those cut from the middle part. Discard tip portions of one-year shoots, since they rarely root well.

The cuttings can be made in late winter and stored in moist sawdust in a cold storage or cool cellar until planting time. During this time the basal ends will callus, the first process necessary for root development. Early planting is essential for obtaining a high percentage of rooted cuttings. Line out the cuttings in early March or as soon as soil conditions permit. If planted later than April, rooting will be poor.

The cuttings are set 2 to 3 inches apart in shallow trenches. When set, the top bud should be just above soil level and the soil firmed well around the cutting.

Hardwood cuttings of quince and the clonal apple stocks root more readily than those of other tree fruits. It is often difficult to root cuttings made from cultivars of apples, peaches, pears, plums, and cherries. The Old Home pear cultivar, used as a blight-resistant interstock, can be propagated by hardwood cuttings. Rooting can be increased by treating the basal ends of cuttings with commercial rooting hormones and by placing the cuttings under mist to keep them continually moist.

Fig. 4—Rooted layers are being sorted into groups of uniform size for further use. Those shoots which did not root may be made into hardwood cuttings for rooting and further propagation, as explained under Hardwood Cuttings.

Fig. 5—Field rooted shoots lined out in the spring for budding in August.

Softwood Cuttings

Very few deciduous fruit plants are successfully propagated by softwood cuttings. Those that respond to this method of propagation are the Mahaleb cherry and selected clones of Myrobalan and European plum. Softwood cuttings of peach rootstock, especially Siberian C, will generally root readily. Mid or basal portions of shoots are preferred, since terminal shoot cuttings often do not root well.

Soft shoots of new growth are selected for cuttings from June to late July. The shoots are cut into 4 to 6 inch lengths with the basal cut just below a bud or leaf and the upper cut just above a bud or leaf. The lowest leaf is removed for convenience in handling and inserting the cutting, but the others should be left on since they will aid in the rooting process. If the basal ends of cuttings are dipped into a commercial rooting hormone preparation, roots will often form more rapidly and abundantly than if not treated. Root promoting compounds are available from garden supply stores or horticultural supply firms.

The rooting medium may consist of sand, peat, vermiculite, or mixtures of one or more of these with soil. It is necessary to maintain moist conditions around the cuttings to prevent wilting of the leaves. Cuttings subjected to as much sunlight as feasible will root faster than if shaded. In modern propagation houses, softwood cuttings are grown under intermittent mist. This method of "mist propagation" permits the use of more sunlight during the rooting period and also keeps the cuttings moist at all times, making rooting possible in a higher percentage of cuttings.

Techniques of Cultivar Propagation

Budding and grafting techniques are used to properly insert the scion in a stock or rootstock. The scionwood should be selected from healthy trees, and, if possible, from indexed virus-free trees. This is particularly true of cherries, peaches, and apples in regard to specific virus diseases. Some state agricultural experiment stations and nurseries maintain trees free of virus that may be a source of scionwood.

There is less chance of mixing cultivars or of obtaining the wrong cultivar if budwood or scions are cut from true-to-name bearing trees. Proper labeling of scions and budsticks is essential for keeping cultivars properly identified.

Most fruit growers will want to purchase their trees from a nursery. However, they may wish to perpetuate a certain cultivar or multiply a cultivar for their own plantings or for the use of others.

BUDDING

All tree fruits grown in Ohio and surrounding states can be propagated by budding, the primary method of propagating all stone fruit cultivars. Budding is used primarily to propagate new trees of a cultivar, but may also be used in top working a tree of one cultivar to another as described later.

Both "T" (shield) budding or chip budding are used effectively in propagating fruit trees. The choice of which budding technique to use is determined by the condition of the bark on rootstocks, the species of fruit involved and the personal preferences and abilities of the propagator.

Techniques for T-budding and chip budding are outlined and graphically described in this section.

Time of Budding

In Ohio, the usual season for T-budding begins in June with some species and may last until the latter part of September with other species. The best time for T-budding depends on the maturity of the buds to be transferred, and on the ease with which the bark "slips" or peels on the stock being budded. High rainfall and vigorous growth in the early growing season favors early development of favorable budding conditions.

Some fruit species complete growth earlier than others, hence should be budded earlier. In general, the plant species complete their terminal growth in the following order, from early to late: Western Sand cherry *(Prunus besseyi)*, European plum *(Prunus domestica)*, pear *(Pyrus communis)*, apple *(Malus sylvestris)*, Mazzard cherry *(Prunus avium)*, quince *(Cydonia oblonga)*, Myrobalan plum *(Prunus cerasifera)*, Mahaleb cherry *(Prunus mahaleb)*, and peach seedlings *(Prunus persica)*. Siberian C peach rootstock is an exception. This rootstock induces early cessation of growth, defoliation and hardening off, often 7 to 10 days before other seedling peach rootstocks.

Chip budding can be used when the bark is not slipping, for example, in early spring before growth begins or during early summer when active growth ceases due to drought or other causes. Chip budding is somewhat more difficult and time consuming than T-budding, but results have been excellent for propagators who become proficient in the technique. Chip budding is especially adapted for use in propagating stone fruits, particularly peaches.

For early season ("June budding"), either in T-budding or chip budding, mature, dormant buds must be used.

Scionwood must be cut before buds begin growth and stored under refrigeration as described for grafting. After the buds have united with the stock, the top of

Fig. 6—A healthy, vigorous shoot of current season's growth is selected for a "budstick." After being cut from the tree, the leaves are snipped off, leaving a short piece of petiole attached to the budstick.

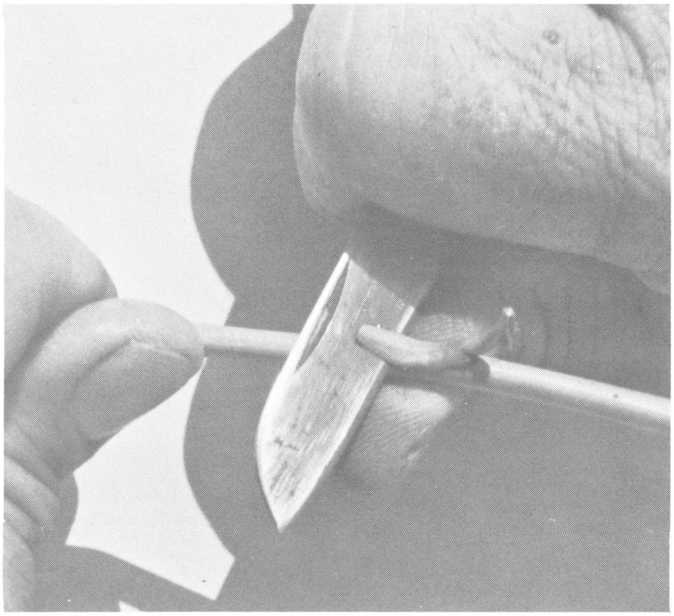


Fig. 7—Cutting the shield bud from the bud stick begins about a half inch below the bud in the axil of the leaf petiole. The cut is made through the bark into the wood, then upward beneath the bud, coming out about a half inch above the bud. The thin section of bark and wood is called the "shield."

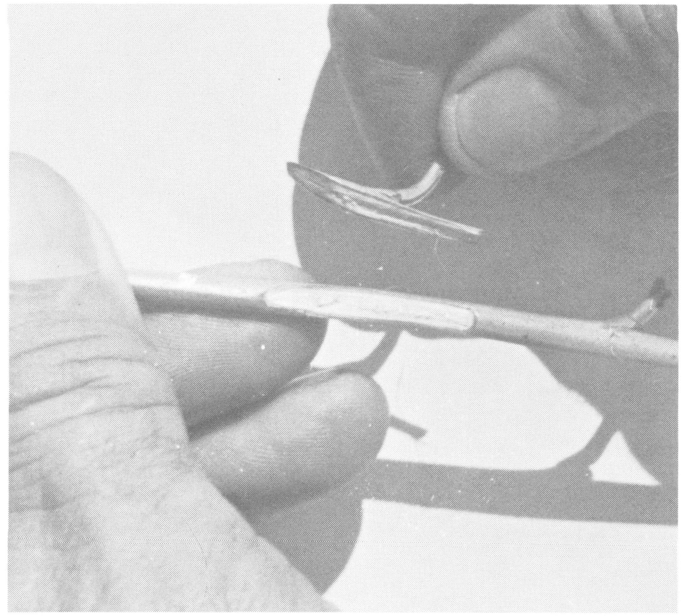


Fig. 8—A shield bud cut from the budstick.

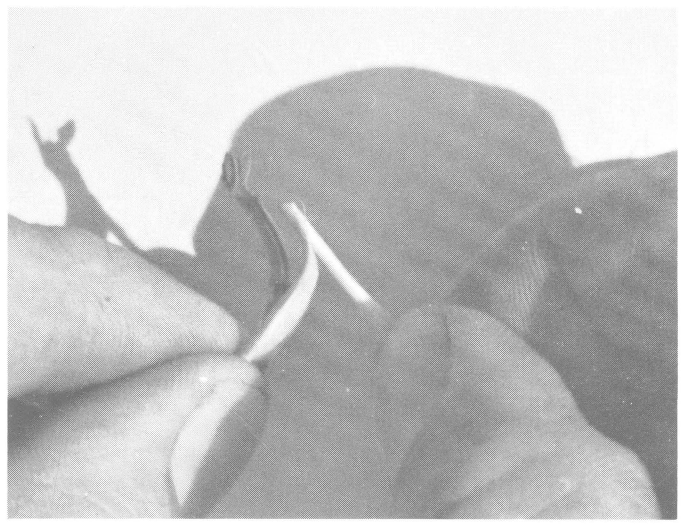


Fig. 9—Removing the sliver of wood from the bark is preferred by some propagators. Others use the shield with wood intact.

the stock is pruned off just above the inserted bud. The bud then grows and produces a tree ready for planting the following spring.

Selection of Budwood

Current season shoots of the desired cultivar provide the only source of budwood (Fig. 6). When collected, these shoots are referred to as "budsticks." Budwood should be selected that has an abundance of leaf buds rather than flower buds.

Vigorous shoots that have formed terminal buds will generally have suitable mature lateral buds. After the shoots are removed from the tree, the leaf blades are clipped off, leaving a short piece of the petiole attached to the shoot. Removing the leaf blades reduces moisture loss from the stock. Further drying out of the budsticks can be prevented by keeping them wrapped in moist cloth or in polyethylene bags with a small amount of moist paper towel. The budsticks are ready for immediate use, or they may be stored under refrigeration at about 34° F until time for budding. If budsticks are to be shipped or mailed, they should be packed in polyethylene bags immediately upon cutting from the tree, without added moisture.

Plump, well-developed leaf buds from the mid-portion of the budstick are the most suitable. Buds from the base of the shoot and from the soft tip should be discarded if sufficient mid-portion buds are available.

Budding Techniques

Techniques used in budding are rather simple and may be mastered easily through practice. Graphic illustrations of the sequence of procedures used in T-budding and chip budding are shown in Figs. 8 through 18-A. Buds are normally inserted in shoots of the current season; however, budding into one- or two-year-old wood, as is the case in top working, can be successful.

T-Budding Procedure

The bud should be inserted in the base of seedling rootstocks at a point one to three inches from the ground. In apple clonal rootstocks used for dwarfing, the buds should be inserted from 12 to 16 inches above ground level. This will make possible deeper setting of the trees in permanent plantings. The steps in budding are as follows:

1. Cut the bud from a budstick in this manner: about a half inch below the bud begin cutting with a sharp blade (Fig. 7); cut into the wood slightly, then upward beneath the bud, coming out about a half inch above the bud. Thus, the bud and petiole stub are attached to a shield of bark and wood (Fig. 8). Some propagators prefer removing the sliver of wood from the bark (Fig. 9); others use the complete shield intact.

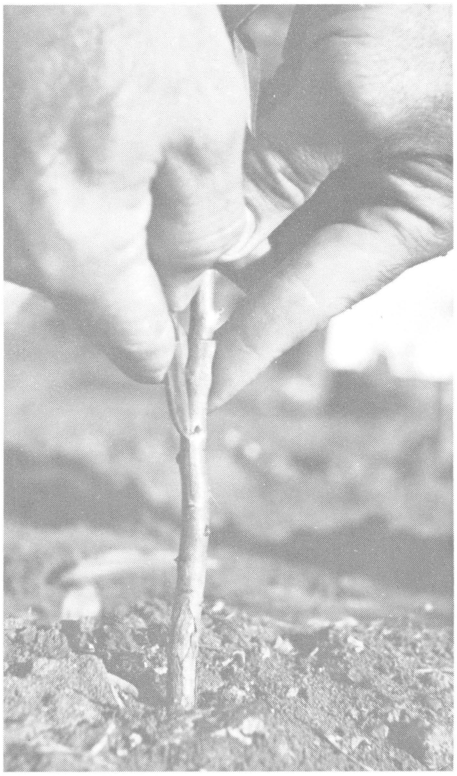
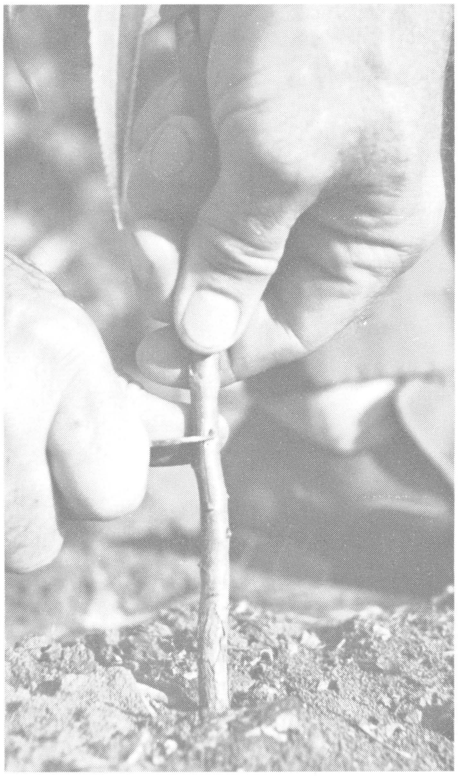




Fig. 10—(Left) A vertical cut through the bark is the first step in preparing the stock for budding. In the case of seedlings, the cuts are made 2 to 3 inches from the ground. With dwarfing stocks, the cuts are made higher on the trunk, 12 to 15 inches from the ground. **Fig. 11**—(Center) The horizontal cut is made across the top of the vertical cut, from ¾ to 1 inch in length. **Fig. 12**—(Right) The bark slips well and can be gently loosened before inserting the bud.

2. Make a vertical cut through the bark of the stock about 1½ inches long (Fig. 10). At the top of this cut, make a horizontal cut (Fig. 11), thus forming the T-cut; then gently spread the bark from the wood (Fig. 12). The bark must slip easily in order for this to be done properly. The stock is now ready to receive the bud.
3. Insert the bud by grasping the petiole stub and gently pushing the shield downward beneath the bark of the T-cut in the stock (Fig. 13). If the bark of the shield extends above the upper cross cut, cut it off even so the under surface of the shield fits snugly to the wood of the stock (Fig. 14).
4. Wrap the bud firmly to hold it in place until union is made with the stock. Special rubber budding strips are now used for this (Fig. 15).

   To wrap with rubber stripping, start below the bud, cross the first turn to hold it in place, continue the wrap up to the bud, then above the bud but not over it, until all the cut surfaces are covered. Place the free end back under the last turn and pull it gently. When released, the stretched rubber strip will then secure the end as long as needed. In this way the wrap is smooth and no knots are needed. Three or four wraps both below and above the bud are usually sufficient (Fig. 16).

   The size of strips varies from 3½ to 5 inches long and from 3/32 to 3/16 inch wide. The size of the stock being budded determines the size used. The smaller sizes are most commonly used in budding nursery stock. The rubber begins to "check" in about two weeks and usually rots off about four weeks after budding (Fig. 17). The strips may need to be cut if the stock is growing very rapidly at the time of budding. This is especially true for stone fruit.

Chip Budding Procedure

Chip budding is generally done on smaller rootstocks or in the case of top-working, on limbs up to 1 inch in diameter.

As shown in Fig. 18-A, page 16, the procedure is as follows:

1. The first cut is made into the scion at a 45° angle, about ¼ inch below the bud. The second cut is started about ½ inch above the bud, cutting inward and downward in a curving motion until it intersects the first cut.
2. At a smooth place between nodes, the same cut is made on the rootstock or limb to be budded. The chip is removed and replaced by the one from the scion.
3. With practice, both the chips from the scion and the rootstock can be cut to the same size and shape, in order to ensure maximum contact of the cambium of the scion with that of the rootstock. It is essential that the cambium be matched on at least one side, preferably on both sides.
4. Unlike T-budding, there are no protective bark flaps to help reduce drying out of the tissue. Thus it is very important to immediately wrap the chip bud to seal cut edges and hold the chip tightly in place. To fasten, use grafting tape, string or bud-

Fig. 13—(Left) The shield bud is pushed gently into place beneath the bark flaps. **Fig. 14**—(Center) The shield bud is in place and ready for wrapping. **Fig. 15**—(Right) A rubber budding strip is used to wrap around the bud to hold it firmly in place.

Fig. 16—(Left) The bud is completely wrapped, thus completing the final step in budding. **Fig. 17**—(Center) Three or four weeks later, the rubber strip begins to check and deteriorate. It usually breaks up before causing restriction of tree growth. If it does not, it should be clipped and removed. **Fig. 18**—(Right) The bud after rubber strip was removed, showing complete union with the stock. The dormant bud will grow the following spring.

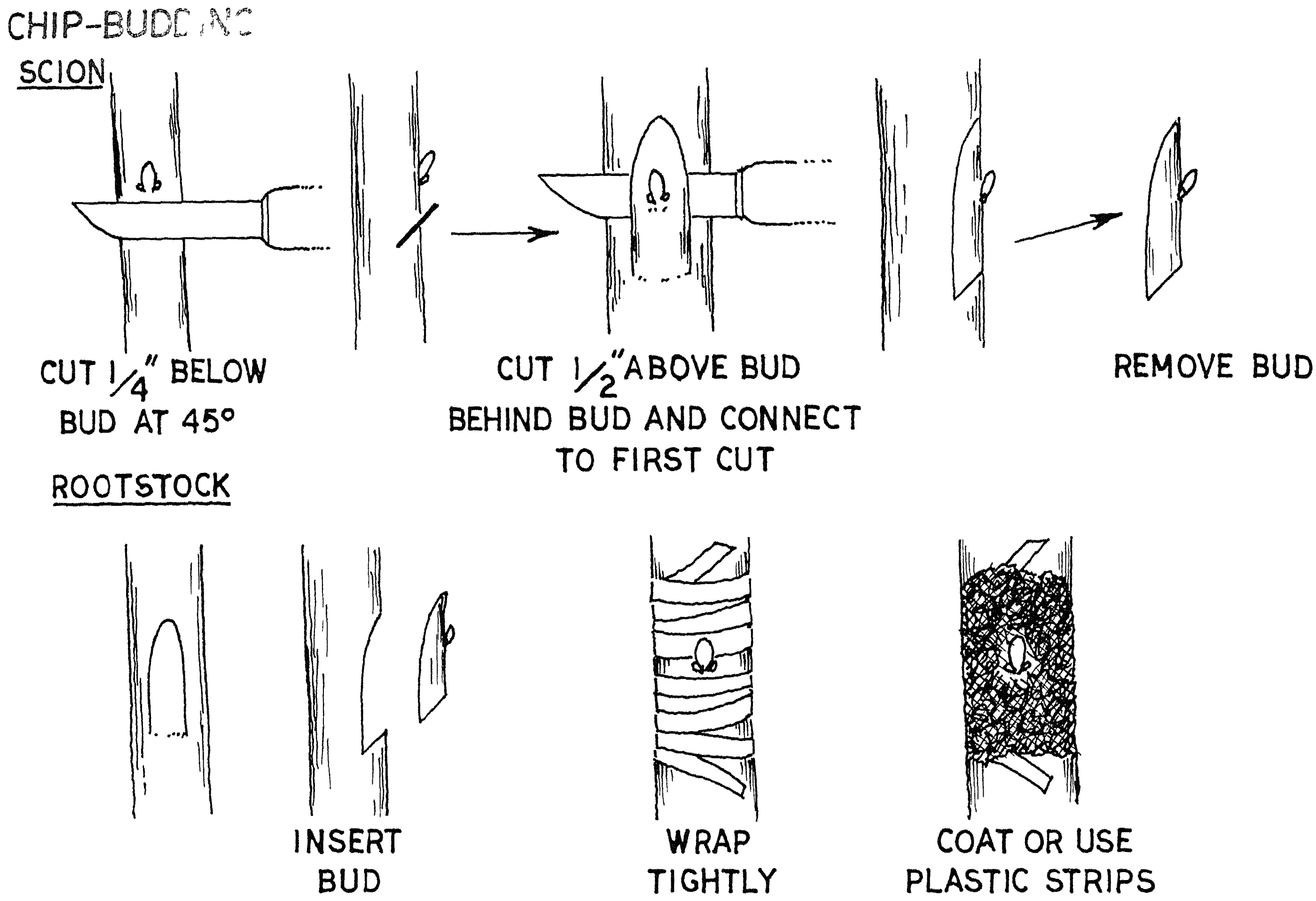


Fig. 18-A—Both T-budding and chip budding are forms of grafting Chip budding is adapted to use in spring when the rootstock is dormant. Fully developed,dormant buds are essential for success in budding

ding rubbers With rubber budding strips, wrap the bud as described for T-budding.

5. To prevent drying, cover the cut surfaces after wrapping with grafting wax, special plastic strips available through horticultural suppliers or cover cuts thoroughly with asphalt base protective coating, leaving the bud exposed.

In chip budding, the stock is not cut back to the bud until growth begins and the union is completed. If chip budding is done in late summer or fall, the stock is cut back just as growth begins the following spring, to permit rapid healing of the cut.

Care After Budding

When budding is done in late summer or fall, the bud will remain dormant over winter (Fig 18) except in rare instances of short growth in the fall. Buds that grow in the fall usually make poor trees or may be winter killed. In early spring, the stock should be pruned off to ½ to ¾ inch above the inserted bud (Fig. 20). In the case of apples and pears, the stocks may be cut off before growth begins. With stone fruits, however, it is best to delay cutting until new growth begins If cut while still dormant, stone fruit buds develop new growth slowly, and some may fail entirely. Mazzard and Mahaleb cherry and peach seedlings are particularly sensitive to pre-growth cutting.

If a bud fails to take, the stock may be budded again If too large for this, the top can be pruned off in the spring thus forcing a new shoot to develop near the ground This shoot may then be budded at the proper time.

Any growth arising from the rootstock below the bud during the growing season should be rubbed or removed as soon as it appears.

Good foliage on the budling (the growth from the inserted bud) during the first season is very important. Cultivation, weed control, spraying to control diseases and insects when necessary, and irrigation during prolonged dry periods can help maintain healthy foliage and produce maximum growth

One-year-old budlings, if large enough, may be dug in the fall and planted in permanent locations. Peach and other stone fruit trees are normally large enough to be dug after one year's growth in the nursery (Fig. 21). Many apple and pear trees are also large enough the first year; however, it remains a common practice in some nurseries to grow these fruit trees two years before digging Good one-year budlings are considered best for commercial orchard plantings (Figs. 22 and 23).

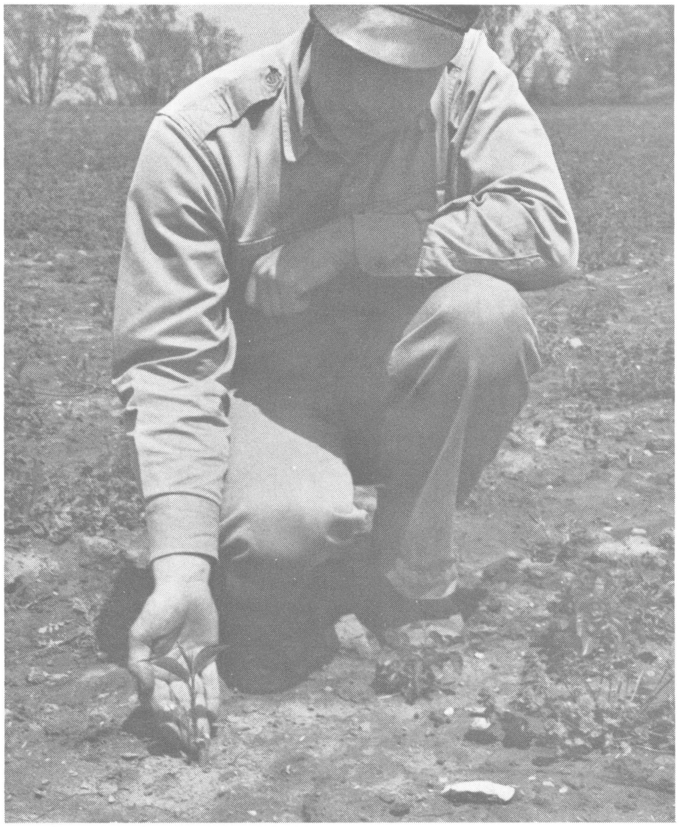


Fig. 19—In the spring following budding, the top of the rootstock is pruned off just above the inserted bud.

Fig. 20—Bud of the cultivar begins to grow into a budling that will be ready for planting in the fall or the following spring.

Fig. 21—Budlings in the nursery row near the end of the first growing season. Such trees may be dug in the fall for storage or sale and planting, or they may be dug the following spring.

Fig. 22—A budded Malling stock in the nursery row at the end of the first growing season. Note the smooth bud union and its position 12 to 15 inches from the soil level.

Fig. 23—Apple trees in nursery row budded the previous August. Cultivar is Golden Delicious on M7 rootstock.

GRAFTING

Several grafting techniques have been perfected. The one to use depends on the conditions under which the grafting is to be done. **Whip grafting,** sometimes called bench grafting, is one of the most common methods in fruit tree propagation. Techniques for whip grafting are described on this page.

Cleft grafting is the technique most frequently used in top working a fruit tree and is explained under the section on top working. Other grafting techniques that may at times be used on fruit trees include **bark grafting, notch grafting,** and **side grafting.** In a broad sense, these may be considered as variations of either whip or cleft grafting.

Whatever the grafting technique used, it is necessary to match as perfectly as possible the cambium of the scion with the cambium of the stock. The stock and scion must line up in the same direction. When this is properly done with two compatible cultivars and the scion is held firmly in place without drying out before healing takes place, the union should be successful.

Grafting procedures as described in this bulletin may be successfully done with pears and quince but is most widely used on apple trees. Grafting of stone fruit cultivars is not as successful, but satisfactory unions may be produced under favorable conditions.

Selecting and Storing Scion Wood

Only dormant wood can be used successfully as scions for grafting. Thus, scions must be cut while dormant and grafted immediately, or held under proper storage conditions until grafting can be done.

Terminal shoots or "water sprouts" of the previous season's growth make the most suitable scions. Shoot growth of 12 inches or more is better than shorter growth, and should have well-developed leaf buds. For whip grafting and top working, scions ¼ to ⅜ inch in diameter work best.

Scion wood should be collected when temperatures are above freezing, and from healthy, virus-free trees in a vigorous state. If not used immediately, dormant scionwood may be stored in a manner that prevents drying of tissues and forcing of buds.

For storing, scions may be cut to suitable lengths, bundled, labeled as to cultivar and packed in slightly moist peat or sawdust or wrapped in polyethylene sheets or bags with some moist material. If kept too moist, scions may mold and be useless for grafting. The storage temperature should be maintained between 32° and 40° F. Temperatures below freezing can result in injury to the scionwood.

Whip Grafting Techniques

This method works best when stock and scion are of similar diameter, preferably between ¼ and ⅜ inch. Seedlings and rooted layers (Fig. 24) are whip grafted in late winter or early spring after they have been dug from the nursery row. Such grafting is generally done indoors and is often called bench grafting.

Whip or bench grafted trees are stored in a manner similar to that of scionwood until time for planting out in the nursery row. During the storage period, the grafting wounds heal and callus, the first step in union of scion and stock.

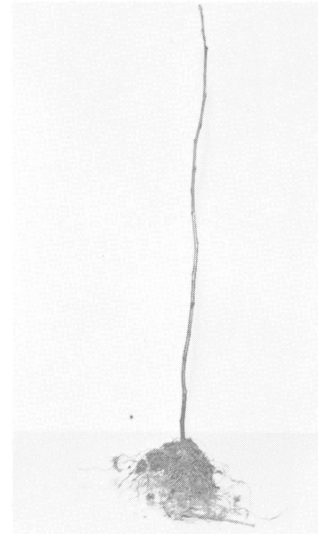


Fig. 24—The rootstock used in whip grafting may be either a seedling or a rooted shoot of clone, as shown here. This is a shoot from a mound-layered M7 apple rootstock.

Storage temperatures may range between 32° and 40° F, and the relative humidity should be maintained fairly high, as near 80 to 85 percent as possible.

Whip grafting techniques can be easily mastered and are performed in the following manner:

1. Cut the scion from the mid-portion of a suitable dormant shoot, so that it has one or two good buds. A single shoot may yield from two to four suitable scions, depending on its length.
2. Make a sloping cut at the base of the scion from 1 to 1½ inches long (Fig. 25). The larger the scion, the longer will be the cut. On the sloping cut surface, about one-third the distance from the tip, begin another cut nearly parallel to the first (Fig. 26), making it from ½ to ¾ inch long.
3. Prepare the end of the stock to be grafted in the same manner as the scion (Fig. 27).
4. Fit the scion and stock together tightly so that the cambiums of the cut surfaces match perfectly on at least one side (Fig. 28). If stock and scion are

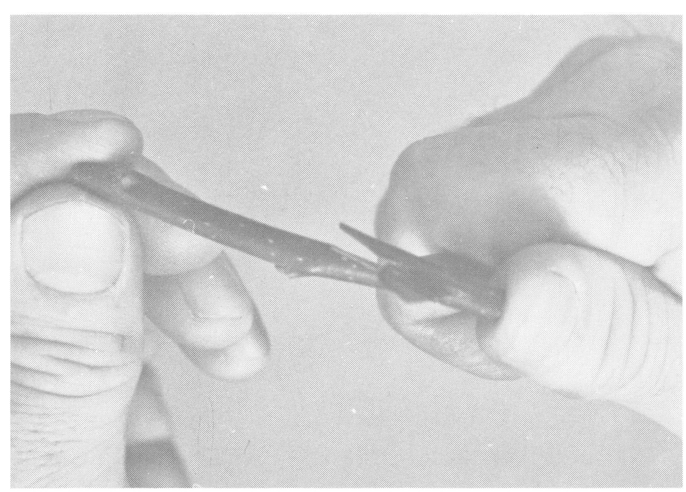


Fig. 25—In whip grafting, the scion is cut so that it contains two good leaf buds. The lower cut, as shown, is sloping with a surface of 1 to 1½ inches long.

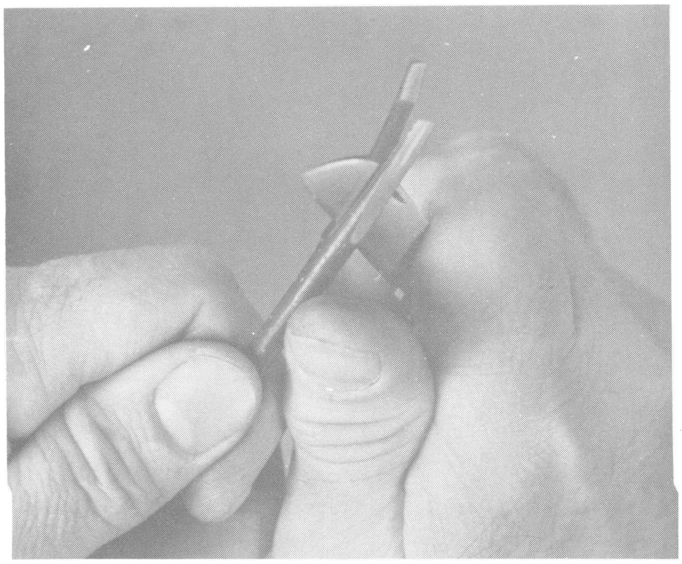


Fig. 26—About one-third the distance from the scion's lower end to the end of the cut, a second cut is made into the center of the scion and nearly parallel with the first one.

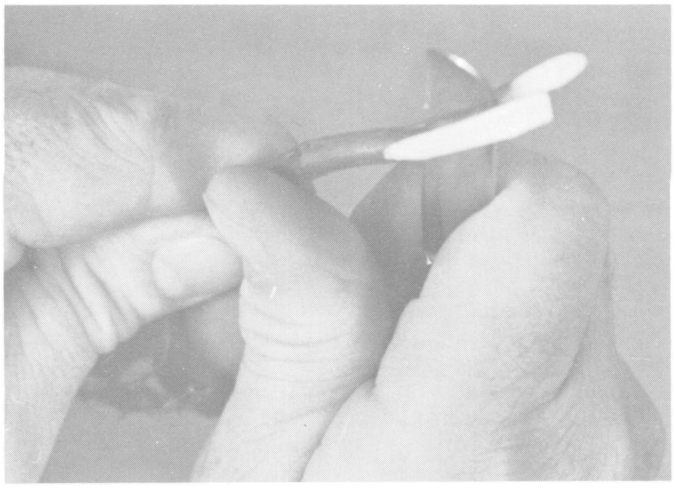


Fig. 27—The upper end of the rootstock is cut and shaped in the same way as the lower end of the scion.

Fig. 28—The scion (right) is slipped on the rootstock (left) in the tongue-and-groove fashion. The cambium of the scion must match as perfectly as possible that of the stock, at least along one side.

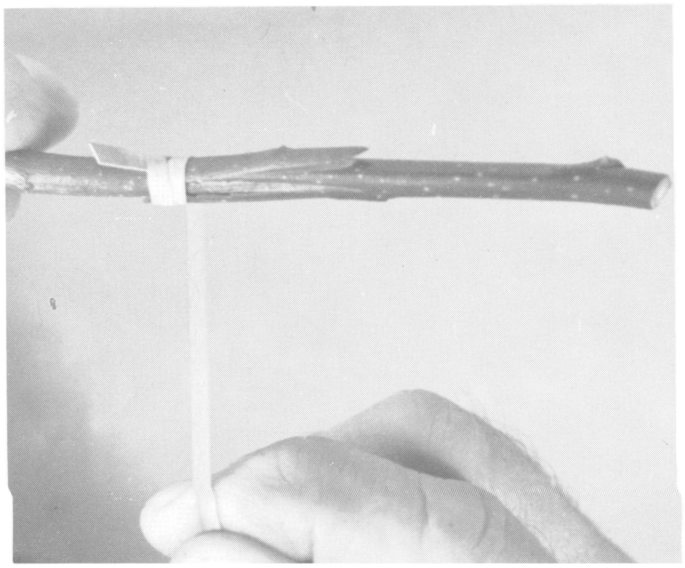


Fig. 29—A special rubber strip (budding strip) can be used to wrap the graft union.

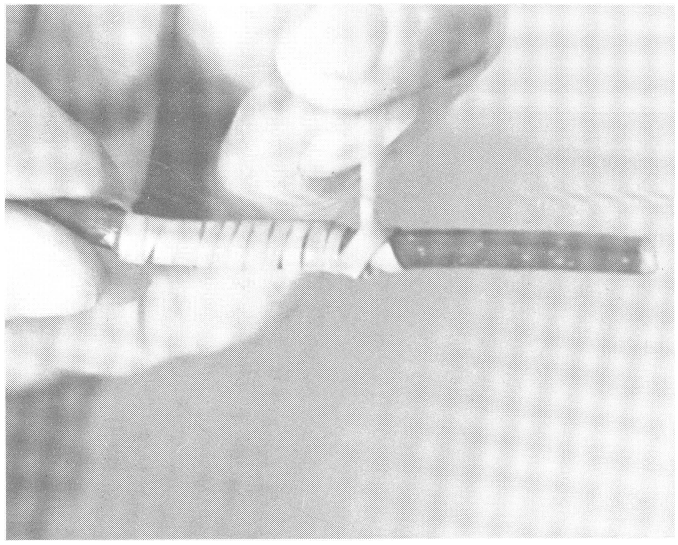


Fig. 30—The graft union is completely wrapped, thus holding the scion in place until growth is complete.

of equal diameters, both sides will match. The toe of the scion should just come to the heel of the stock.

5. Tie the graft firmly by wrapping it with a rubber strip (Figs. 29 and 30) grafting tape, raffia, or other suitable material. If the wrapping material does not decay and break as growth takes place, it should be cut about a month after growth begins.
6. Coat the graft unions completely to prevent drying of tissues (Fig. 31). The cut surface on the scion tips should also be sealed (Fig. 32). (See section on waxes and tools for grafting.) (See Figs. 31 and 32, next page.)

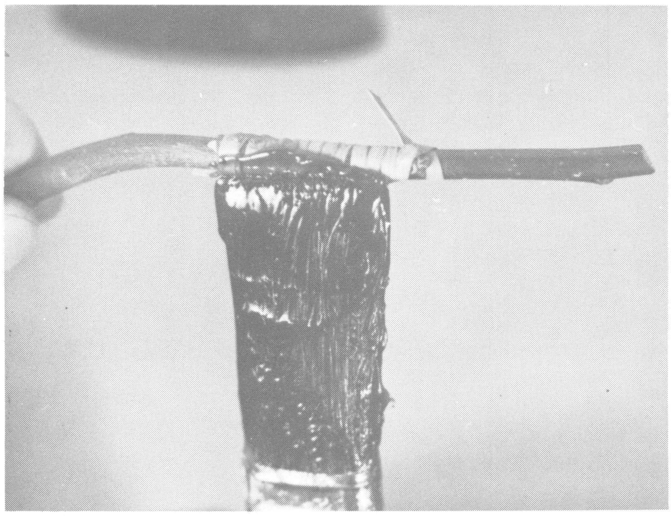


Fig. 31—Asphalt compound or grafting wax is applied to keep scion and tissues from drying out. The graft union is completely covered. Buds on the scion should not be covered.

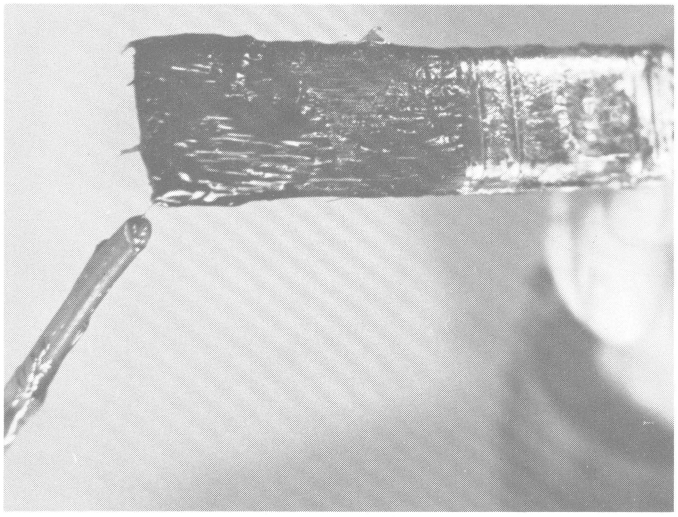


Fig. 32—The tip of the scion is also coated.

Care After Grafting

Seedlings or clonal stock that have been whip grafted are generally planted in nursery rows. The trees are spaced about a foot apart in the row, and the rows are made four feet apart.

If both buds on the scion start growing, the one with the shortest growth should be pruned off soon after growth begins. This leaves a single shoot to grow into the new tree (Fig. 33). Competing shoots that may arise from the stock below the graft union should be removed as soon as observed during the first growing season. These can be rubbed or snapped off by hand when they are under 5 or 6 inches in length. After growth has begun, it is generally necessary to cut the tying material since it will not decay readily under the protective coating.

The soil around the trees and between rows should be shallow cultivated and hoed as needed to control grass and weeds during the growing season. Spraying may be necessary occasionally to keep leaf-feeding insects and foliage diseases under control. Irrigation during prolonged dry periods will help maintain constant growth and the production of suitable size trees.

After growing in the nursery row one season, most grafted trees are ready for permanent planting the following spring (Fig. 34). Smaller trees may be left in the nursery row or transplanted to another nursery row for a second year's growth before being moved to permanent plantings. One-year trees, or whips, of suitable size are most satisfactory for commercial orchard plantings. Labeling trees with metal, plastic, or other long-lasting labels aids in keeping nursery stock properly identified.

Interstem Grafting—Double Worked Trees

Extensive planting of dwarf apple trees in high density commercial orchards has resulted in various cultural systems designed to maximize yield and fruit quality. Trees on M 9 or M 26 rootstock are commonly used for the highest density plantings. Since M 9 has brittle roots that are easily broken, support by staking or trellising is always required. Similarly, M 26 may require staking, especially when fruiting places heavy stress on the root system.

Interest in reducing or eliminating support systems in high density plantings has renewed interest in interstem trees. Interstem grafting consists of inserting a special stem between the rootstock that is self-supporting and the top scion cultivar (Fig. 35). Some dwarfing effect can be accomplished with this procedure.

Interstem combinations now commonly available through commercial propagators consist of the scion cultivar grafted or budded to an 8 to 10 inch stem piece of M 9 propagated on MM 111 or seedling rootstock. In some cases, special interstems have been selected for compatibility and hardiness.

Although research is somewhat limited to date, initial results indicate interstem trees of these combinations are self-supporting. However, the dwarfing effect is not as great as if the cultivar were grafted directly on the dwarfing rootstock. With M 9, the degree of dwarfing achieved is related to length of the interstem used. Whenever M 9 is used, the interstem should be at least 6 to 8 inches long. Little additional decrease in tree size is noted with interstems longer than 12 inches. For uniformity, all interstems in a particular rootstock-scion combination should be the same length.

Interstem grafting may be accomplished, using one of three techniques as described below:

Double Grafted Interstems

Two whip or bench grafts may be made to join the rootstock, interstem and scion in a single operation.

With any rootstock, the lower whip graft should be high enough to allow for deep planting and improved anchorage. If available 10-16 inches of stock should be retained. This is especially important where M 7 is used as the clonal rootstock. Use at least 6-8 inches of interstem with sufficient scionwood (3 to 4 inches) to allow for ease of handling and 2 to 3 healthy buds. Both unions and the scion tip should be coated with grafting wax or asphalt emulsion as described under whip grafting techniques (p. 18).

The grafted stock is lined out in the nursery row in early spring or may be set directly in place in the orchard. If immediate planting is not possible, the trees may be held in refrigerated storage as described for storage of scionwood (p. 18).

Fig. 33—(Left) A grafted rootstock in the nursery row. Upper bud of the scion has started satisfactory growth. Growth from the lower bud has been removed. **Fig. 34**—(Center) Growth from a graft at the end of the first season in the nursery row. The tree, a one-year whip, will be ready for transplanting in the fall or the following spring. **Fig. 35**—(Right) A two-year-old apple tree with the interstem piece of M9, the enlarged segment used to induce dwarfing. The root system is that of an apple seedling and the top scion cultivar is Jonathan. The interstem piece of M9 should be at least 6-8 inches in length.

The degree of success in obtaining union of two grafts in double working trees is dependent on use of proper techniques and careful attention to handling and care of the trees. All shoot growth arising from buds on the rootstock and interstem must be removed early after planting to encourage graft healing and vigorous scion growth. As with single worked trees, one strong growing shoot should be retained on the scion cultivar to form the first year single whip tree.

Single Grafted and Budded Interstems

As with double grafted trees, bench or whip grafting may be used. A 6 to 8 inch scion of the dwarfing stock is grafted to a one-year seedling. The grafted stock is then lined out in the nursery row in early spring. In mid-summer, the desired apple cultivar is budded onto the interstem at least 6 to 8 inches above the previous graft union. The tree is then handled as any other budded tree in the nursery row. This method requires two years to produce a tree suitable for planting.

Double Budded Interstems

In the third technique, buds from the dwarfing stock are inserted in the seedling rootstock while it is growing in the nursery row, at the most suitable time in mid-summer. In mid-summer of the following year, the desired cultivar is then budded onto the resulting whip growing from the inserted dwarf stock bud. The cultivar bud is inserted 6 to 8 inches above the previous bud union. This technique requires three growing seasons to produce a plantable tree. This disadvantage, however, may be outweighed when large numbers of trees are propagated, since less scionwood is needed than in the previous methods.

The double-budding technique is particularly adaptable to the propagation of dwarf pear trees. Some cultivars such as Bartlett do not make strong unions with the quince dwarfing rootstock. This can be overcome by first budding a cultivar to the quince stock that is compatible with it such as the blight-resistant Old Home. Then the following year, the desired cultivar can be budded onto the interstem cultivar, which is compatible with both the rootstock and the cultivar desired for its fruit.

Top Working Procedure

It is sometimes necessary or desirable to change the top cultivar of a tree. This may be done while the tree is still growing in the nursery row or after it has grown one or more years in its permanent location. The process of grafting scions of the desired cultivar onto the framework branches of the tree is termed "top working" or "top grafting." Through top working, a tree containing two or more cultivars may be produced. Such trees are especially of interest for home plantings.

All methods of propagation may be employed in top working. Budding and whip grafting (Fig. 36) are frequently used on young trees that are one to four years of age, and where branches are small enough to accommodate these methods. In the case of peaches and other stone fruits, budding is universally used. With older apple and pear trees, cleft grafting, as described later, is usually used.

Branches that are more than an inch in diameter lend themselves especially well to this technique.

Trees up to 4 or 5 years of age (Fig. 37) may be top worked entirely at one time. Larger trees should have the operation spread over two or possibly three years, top working one-half or one-third of the top each year. It is impractical and unprofitable to top work large mature trees, especially after 10 to 12 years of growth.

The number of scions that can be inserted in any tree depends largely on its size, and whether the tree is completely worked over in one year (Fig. 38). Obviously, the older or larger the tree, the greater the number of scions that will be needed. When a young tree, 3 or 4 years of age, is top worked, it may require from 1 to 3 or 4 scions on each main scaffold branch, or from 12 to 20 per tree. Older and larger trees may require from 50 to 100 scions per tree. On larger trees, it may be necessary to set the grafts farther from the main trunk than on younger ones because that is where the most suitable diameter wood is located.

A few small branches should be left on the tree framework the first year, especially on larger trees. These grow and provide shading of the grafts. By the second year, the new scions will have made enough growth to shade unions and stub areas (Fig. 39). The growth from the original tree framework can then be pruned off (Figs. 40 and 41). From then on, all new growth from the original tree should be pruned off annually, thus permitting

Fig. 36—A two-year-old apple tree that has been top worked by whip grafting. The four main scaffolds and the central leader were grafted to a single cultivar at the same time. The trunk and framework branches could be that of a particular hardy cultivar, or they could carry resistance to the fireblight disease.

Fig. 37—An apple tree of this size can still be satisfactorily top worked and have the top changed to another cultivar.

Fig. 38—The same apple tree as in Fig. 37 after top working by cleft grafting. Seven main scaffold branches were grafted to a new cultivar. Five branches of the original tree remain to provide some shade for the grafts and tree framework. These will be pruned off the following spring.

maximum growth of the new scion cultivar and hastening its time of bearing fruit.

One use of top working is in the production of pear trees with a fireblight-resistant framework. Here the practice is to use seedling pear as the rootstock, or quince for dwarf trees, and to bud or graft the Old Home cultivar onto it in the nursery row. This cultivar has a high degree of blight resistance. Following the second growing season of the Old Home scion, it is top worked to the desired cultivar, such as Bartlett. In this

Fig. 39—The top-worked apple tree in Fig. 38 the following spring.

Fig. 40—The same tree after all the original tree was pruned out, leaving only the grafted branches.

Fig. 41—The same tree after some of the grafts were thinned out. The tree is off to a good start and may bear a few fruits the following year.

way, if the cultivar blights and kills one or more branches, new shoots from the Old Home framework can be rebudded or grafted, thus preventing loss of the entire tree.

Top working can be used to develop a winter-hardy intermediate stock between the rootstock and the scion cultivar. With the apple, a hardy cultivar is budded or grafted to a suitable rootstock such as a seedling or one of the Malling or Malling-Merton clones. This scion cultivar grows for one to three years or until a suitable number of scaffold branches have developed for top working. The scaffold branches are in turn budded or grafted to the cultivar desired for production. This practice has made possible the growing of certain apple cultivars in northern climates that otherwise would experience severe low temperature injury to the trunk and body of the tree. Some of the hardy intermediate stock cultivars of apples that may be used successfully are Antonovka Shafran, Columbia, and Kulon Kitaika. These are cultivars of foreign origin, hence scion wood or trees of these are not readily available. Scionwood of these may be obtained from certain agricultural experiment stations in this country.

Particular factors to be considered in top working are:

1. Branches to be top worked must be properly selected as to size, position on the trunk and number. In the case of cleft grafting, an upright branch of 1 to 2 inches in diameter will give the best results.
2. Those parts of the tree being grafted should not be exposed to sunscald. Neither should scions be placed where they will be heavily shaded during the growing season.
3. The new cultivar must be compatible with the one being top worked. There are few problems of incompatibility between cultivars of a given species. There may be problems when a cultivar of one species is top worked on a cultivar of another species such as European plum on Japanese plum, peach on apricot, apple on pear, or pear on quince.
4. A sound graft union must be made, regardless of technique used.
5. If budding is used in top working, buds may be inserted in one- or two-year-old wood as well as in shoots of the current season.

CLEFT GRAFTING

The cleft graft is made by inserting a scion into a carefully made split in the stub remaining after cutting off a branch, or in the case of a small tree, the trunk. Such grafts can be successfully made on stocks that are between 1 and 2 inches in diameter. The grafting can be done in late winter or after growth starts. Results are best when it is done just before spring growth begins, but dormant scions must be used.

The procedure in cleft grafting is fairly simple, but does require a special tool to do it properly and efficiently. The steps in making a cleft graft are as follows:

1. Prepare the stock by sawing off squarely the branch or trunk, then split carefully with the grafting tool and mallet (Fig. 42). The split should be across the center of the stub and extend downward 1½ to 2 inches, depending on the size of the stock and the scion to be used. Avoid splitting through knots or pruning wounds. The split, or cleft, is opened with the chisel end of the grafting tool (Fig. 43) ready for inserting the scion. Stocks of large diameter may have a scion placed in each end of the split.

2. Cut the scion in the shape of a wedge at the basal end (Fig. 44). One side of the wedge should be slightly narrower than the other. Each cut should be made about 1½ inches long with a single stroke of the knife and tapered evenly towards the end. If the scion is not cut in this shape, it will make contact with the stock only at the thickest portion. The other end of the scion is cut off so that 2 or 3 buds remain above the wedge cuts.

3. Insert the scion in the side of the opened cleft of the stock, with the narrow side towards the center (Fig. 45). Push it gently into position so the scion cambium matches the stock cambium. If a small scion is placed in a large stock, the matching is not as easily done since the thickness of bark tissues will vary considerably between the stock and scion. If

Fig. 42—In cleft grafting, the grafting tool is used to split the branch stub for receiving the scions.

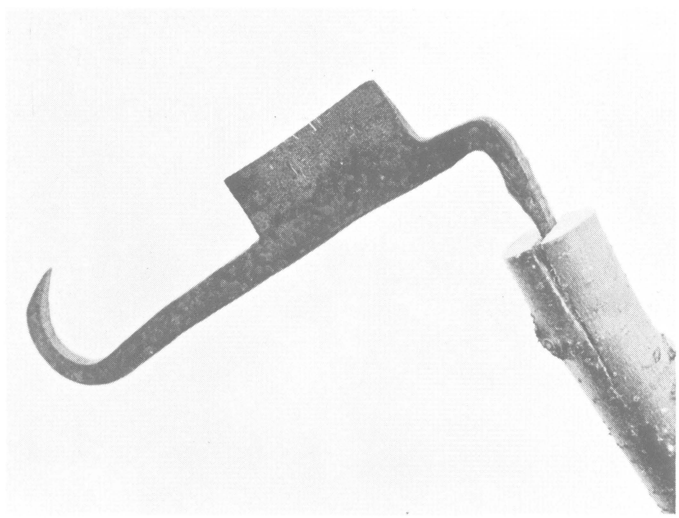


Fig. 43—Chisel end of the grafting tool holds the split open while the scions are inserted.

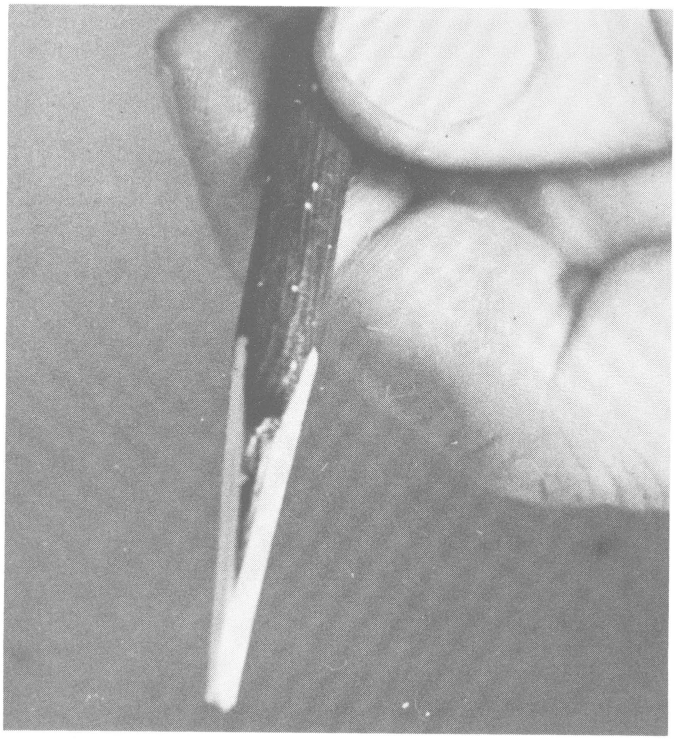


Fig. 44—The scion for cleft grafting is cut in a wedge shape on the lower end. One side of the wedge is slightly thicker than the other. The thin edge goes to the inside of the stock, and the thick edge to the outside where its cambium will match that of the stock.

Fig. 45—The scions are inserted, one at each end of the split or cleft. Cambium of the scion must match as perfectly as possible that of the stock if union and growth are to result.

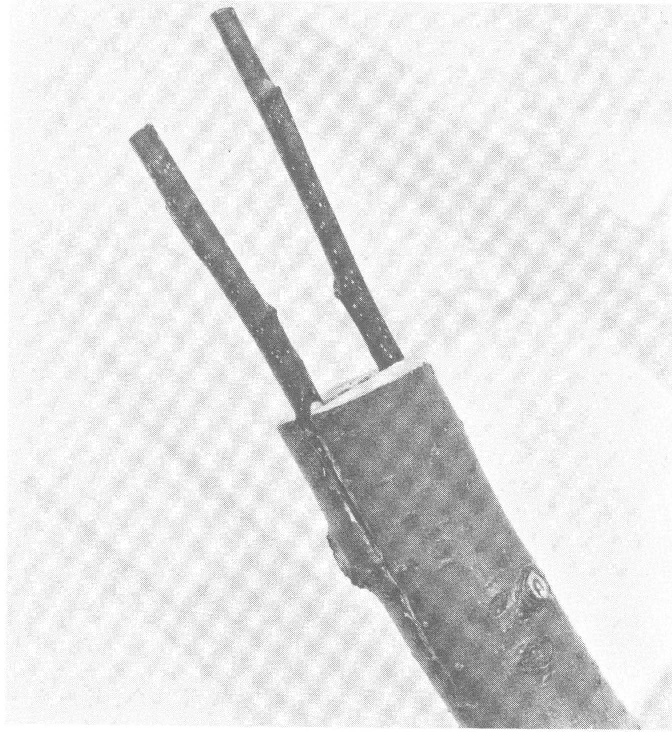


Fig. 46—The two scions in place and the grafting tool removed.

necessary, slant the scion slightly so that its cambium will contact at least a part of the stock cambium. Larger stocks will take two scions (Fig. 46). If this is done, the point of contact should begin about ¼ inch below the shoulder of the stock. Once the scion is in place, remove the grafting tool. Pressure of the stock will hold it in position.

4. Coat all cut surfaces including the scion tip (Figs. 47 and 48) with wax or asphalt emulsion. Complete coverage is necessary, especially in the cleft and on the sides of the stock. It's a good practice to check the grafts periodically during the growing season to make sure that the covering remains intact. Recoat if necessary, but do not cover buds. If the cut surface of stock or scion begins to dry out, then union will not take place. Some attention must be given to the grafts after they begin to grow. It is best to allow all growth from scions to develop during the first season. Shoots that begin to grow very vigorously may be pinched back in early June to induce branching. After the first growing season, light pruning will need to be done, see Figs. 47 and 48 next page.

BARK GRAFTING

The bark graft may be used in place of the cleft graft in top working, and especially in making grafts on rather large diameter stubs. Some grafters prefer this method because it does not involve splitting the stub, and a higher percentage of "take" is achieved.

Bark grafting is done in the spring at the time when the bark separates easily from the wood. The scion is prepared with a single cut about 1½ inches long on one side of the basal end, thus making this portion of the scion wedge-shaped (Fig. 49-A). A short, sloping cut, about ½ inch long, is made on the opposite side of the longer cut, forming a beveled end on the scion. A

Fig. 47—Grafting wax (or asphalt coating) is applied to the scion tip. This prevents drying of the tissues and hastens union of stock and scion.

Fig. 48—Grafting wax is being applied to the cut surfaces of the stock to prevent drying of tissues. If scion and stock tissues dry, union may not take place.

shoulder is cut at the upper end of the longer cut, so the scion will fit over the top of the stock stub.

The branch is cut off as in cleft grafting, then a section of bark is removed from the top of the stub with the exact dimensions of the beveled end of the scion.

The prepared scion is held in place on the outside of the bark. With a sharp knife, the bark is cut to correspond with the length and width of the wedge-shaped end of the scion (Fig. 49-B). The lower end of the scion, with the long bevel towards the stock, is then pushed under the bark between the two cuts, thus, separating the bark from the wood (Fig. 49-C) as the scion is pushed downward (Fig. 49-D). The lifted bark is then cut off even with the top of the short bevel on the outside of the scion. The scion is tacked with two small brads or nails to hold it firmly to the stock. All cut surfaces of the graft union should be thoroughly waxed, as well as the tip of the scion. While some wax on the buds will do no harm, heavy coatings should be avoided.

If the stock is large enough, additional scions can be placed in a single stub. These should be spaced 2 to 4 inches apart.

There are variations to bark grafting, but all use the same basic principle. Some prefer leaving the stock bark intact and tacking it with the scion to the stock. There are also variations in shaping the beveled end of the scion.

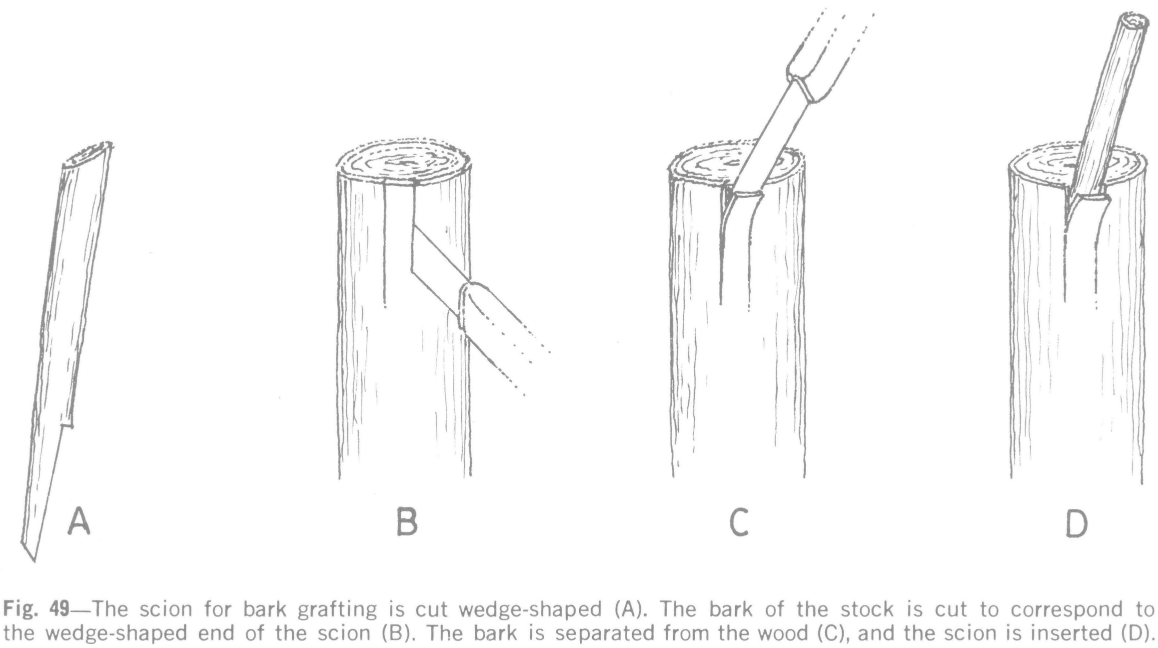


Fig. 49—The scion for bark grafting is cut wedge-shaped (A). The bark of the stock is cut to correspond to the wedge-shaped end of the scion (B). The bark is separated from the wood (C), and the scion is inserted (D).

Special Applications of Grafting Techniques

BRIDGE GRAFTING

Bridge grafting is primarily used to bridge over a dead or wounded area on a tree trunk or main scaffold branch. It is frequently used to repair trees damaged by meadow mice feeding on the base of the tree or by rabbits feeding on the trunk and lower branches of young trees. Apple and pear trees can be most effectively bridge grafted.

Bridge grafting can be done easily when the bark slips well, which is usually after spring growth begins. It may be done anytime up to bloom or even later, providing dormant scions are available. The procedure is rather time-consuming and some practice is necessary in order to develop the skills that lead to successful bridge grafts.

In preparing the area to be bridged over, carefully remove all dead and injured bark tissue, exposing healthy, live bark on all edges (Fig. 50-B). Vertical cuts 2 to 4 inches long are made through the bark where the ends of the scions are to be inserted. These cuts are spaced about 2 inches apart and opposite each other across the injured area.

Dormant water sprouts of suitable lengths make the best scions. Each sprout is cut so that it is slightly longer than the distance between the extremities of the two bark cuts opposite each other. Each end is then shaped into a wedge with beveled points (Fig. 50-A), in the same manner as described for bark grafting, except that no shoulder is left.

The bark along one of the slits is gently lifted with a knife blade or sharpened stick, the end of the scion slid under the bark and into place with the cut surface adjacent to the wood of the tree. The same procedure is followed with the other end of the scion, then both ends are tacked down with one or two small brads. Since the scion was slightly longer than the area bridged, it will have a slight bow (Fig. 50-D). This puts tension on the ends of the scion, helping to hold it in place. Scions are spaced about 2 inches apart (Fig. 50-D).

When all the scions needed to bridge the area are in place, the graft unions and all exposed live bark surfaces are covered with a coat of wax or asphalt compound.

As in bark grafting, there are also variations in the bridge grafting technique. Shaping of the beveled ends of the scions may be varied, especially to fit different types of cuts in the bark on the tree being grafted. In the case of mature trees and bark which doesn't slip easily, it is necessary to cut a section of bark completely from the area where the scion is to fit. This must be done carefully so the beveled surface of the scion fits snugly into the area from which the bark was removed. The scions are tacked in as previously described.

If buds on the inserted scions begin to grow during the first year, the young shoots should be rubbed off as soon as noticed. If growth is permitted to continue, the graft unions may be weakened or even fail completely. Since young bridge grafts are subject to rodent

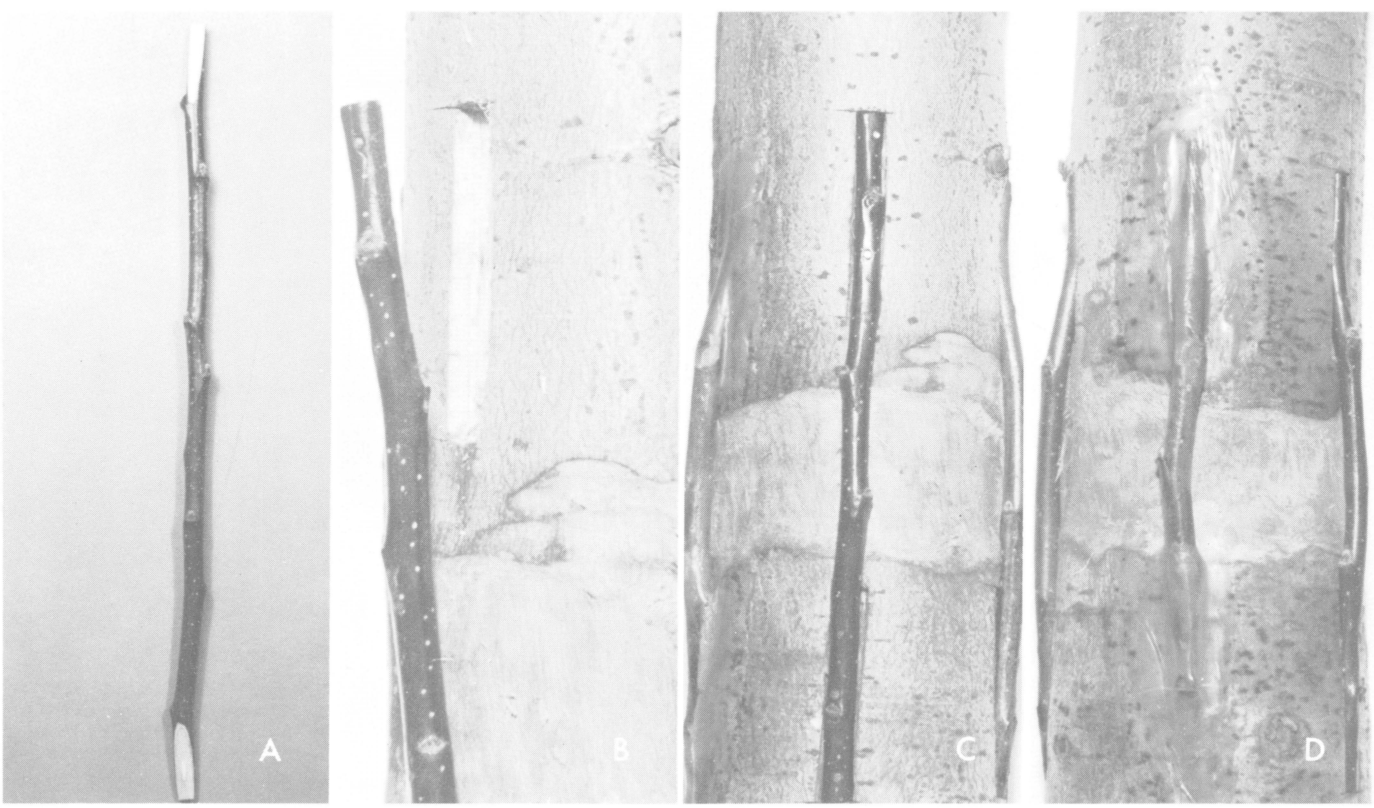


Fig. 50—Bridge grafting procedure: (A) Scion is cut the proper length and both ends beveled for insertion. (B) Section of bark is cut from healthy tissue above the wound area and of the same dimensions as the beveled end of the scion. A similar cut is made below the wound area to be bridged. (C) Scion in place, bridging the wound area on the tree trunk. Two small brads hold each end in place. (D) Ends of inserted scion after properly waxed. Also note the slight bow in the two adjacent scions which helps to hold them firmly in place.

injury, they should be protected with hardware cloth, aluminum mesh foil, or other suitable coverings as soon as the grafting is completed.

INARCHING

Occasionally, extensive injury to the lower trunk and root system occurs, making the wounded area unsatisfactory for bridge grafting. In such cases the process of **inarching** the ends of trunks or branches of seedling trees into the live bark area above the injury of the trunk can bring about satisfactory tree recovery. As with bridge grafting, this method is usually successful only with apple and pear trees.

One-year-old seedlings are planted around the tree and as close to the trunk as possible. In planting, the young trees should be slanted towards the trunk of the injured tree. Space seedlings 6 to 8 inches apart around the tree, using a sufficient number to bridge over the injured area properly.

Dead and injured bark is first cut away from the injured trunk, exposing healthy bark tissue. The ends of the seedlings then may be prepared and inserted beneath the tree bark in the same way as in bridge grafting (Fig. 51). If necessary to bridge over an extended dead area, the end of the seedling may be bark grafted to the trunk or main scaffold branch higher up on the tree (Figs. 52 and 53). The technique is the same as bark grafting. Such grafts should be protected from rodent injury as in the case of bridge grafting.

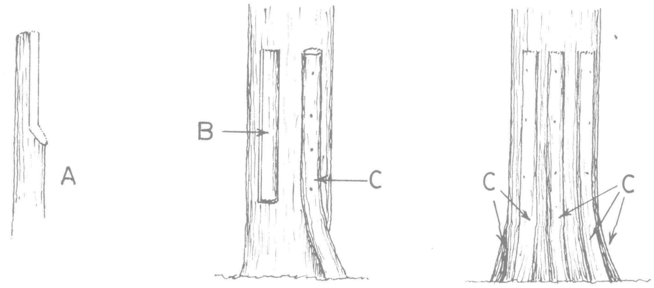


Fig. 51—Inarching procedure: (A) end of seedling with slice cut from the end of the seedling on the side nearest the injured tree; (B) slot cut in the bark of the tree trunk to match the cut end of the seedling; (C) end of the seedling inlaid in the bark slot and held with small brads.

Fig. 52—Inarching with seedling apple trees saved this tree which was girdled by meadow mice at ground level. Ends of the seedlings were inlaid in the healthy bark of the tree trunk, and coated with a wound dressing.

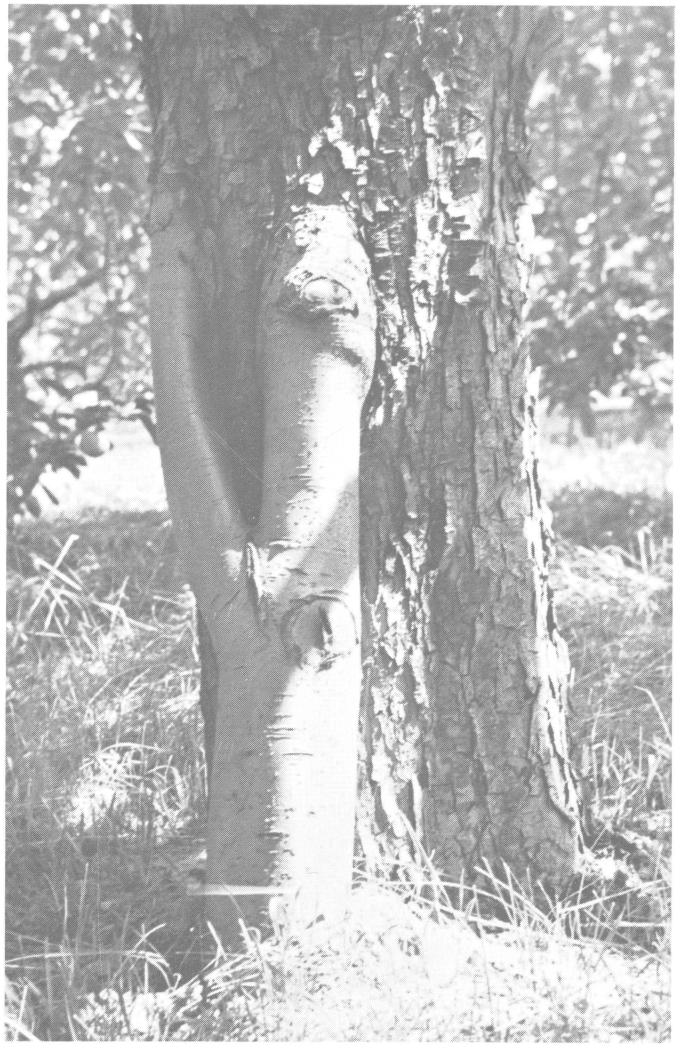


Fig. 53—The base of this apple tree was partially girdled by meadow mice several years ago. By inarching a young apple seedling into the trunk, the tree was saved and its productive life extended indefinitely.

Grafting Tools and Protective Coatings

TOOLS

The tools and equipment (Fig. 54) normally used in budding and grafting can be purchased from garden and orchard supply stores, or from nurseries and special dealers. The essential tools are pruning shears, knives, saws, cleft grafting tool, mallet or suitable hammer, sharpening stones and a supply of No. 18 brads for bridge grafting.

The grafting tool (clefter) used in cleft grafting can be made in the farm workshop by shaping a hard piece of steel to the illustrated form. The appropriate edges are then sharpened as illustrated. The cutting edge may be either straight or concave. A concave cutting edge makes smooth edges for receiving the scions by cutting the bark before the wood can split and tear the bark away. Most tools used in cleft grafting have straight edges and when used carefully will split the branch little beyond the desired limit.

Budding and grafting knives should be made of good steel and kept razor sharp at all times. A dull knife can be the cause of poor healing and poor union of scion with stock. A grafting knife should have a straight-edged blade; a budding knife with the edge curving upward at the point works best. It is the sharp curved end of the blade that is used most to cut the bark for insertion of the buds.

PROTECTIVE COATINGS

All grafting wounds need to be covered with a protective coating immediately after completion of the graft. Characteristics of a suitable grafting wax or other protective coating are:

1. Retains the moisture in the wood and excludes air and fungi from the wounds.
2. Contains no material that would injure live tissue in the strength recommended for use.
3. Has sufficient body to fill cracks easily and is convenient to handle.
4. Elastic enough to accommodate changes in dimension of stock and scion resulting from growth.
5. Neither cracks in cold weather nor runs in hot weather.
6. Is relatively inexpensive.

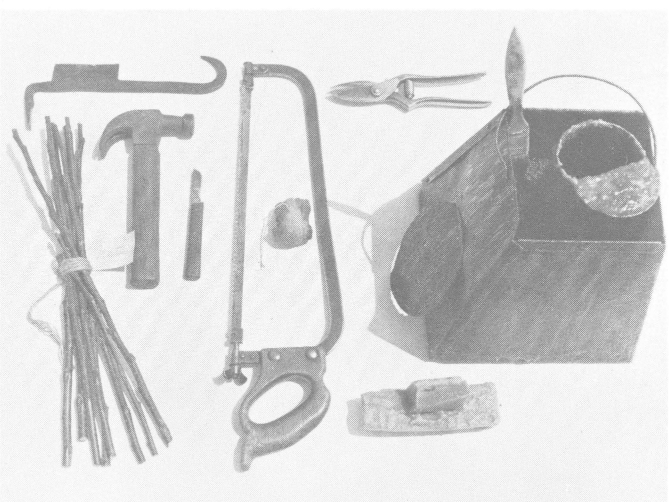


Fig. 54—Tools and supplies needed in grafting: scionwood (cultivar labeled), cleft grafting tool, hammer, grafting knife, pruning saw, pruning shears, wax, container for wax, brush, and a unit for heating wax to melt it while it is being used. (An alcohol lamp provides the heat in this unit.)

Asphalt Emulsion Compounds

Asphalt-water emulsion dressings are now widely used as protective coatings on graft unions, other cut surfaces or injuries on trees. Such compounds are readily available from garden supply stores and orchard supply firms, and are generally preferred to grafting waxes.

Asphalt emulsions have certain advantages over hot waxes, or even hand waxes. They can be thinned with water to the consistency desired for a particular use. They can be applied cold, and they crack less readily in sudden changes of temperature than waxes. They adhere well to the surface of fresh wounds such as those made in grafting.

Asphalt coatings used for roof repair are not suitable for grafting. They may contain compounds toxic to plant tissue.

Brushes, tools, or hands soiled with asphalt may be easily cleaned with fuel oil or kerosene before washing with soap and water.

Grafting Waxes

When hard waxes are used for coating graft unions, a heater is needed to melt the wax and keep it thin enough for application. A small unit equipped with an alcohol burner, as illustrated, is adequate.

Most of the older grafting waxes require heating to bring them to the proper consistency. Some waxes are pliable at hand temperature and are called hand or soft waxes, requiring no other source of heat. These, however, are no longer recommended.

Any wound coating should be inspected periodically to make sure it is still intact. If it has broken away or "checked" badly before healing is complete, a new coating should be applied over the old one.

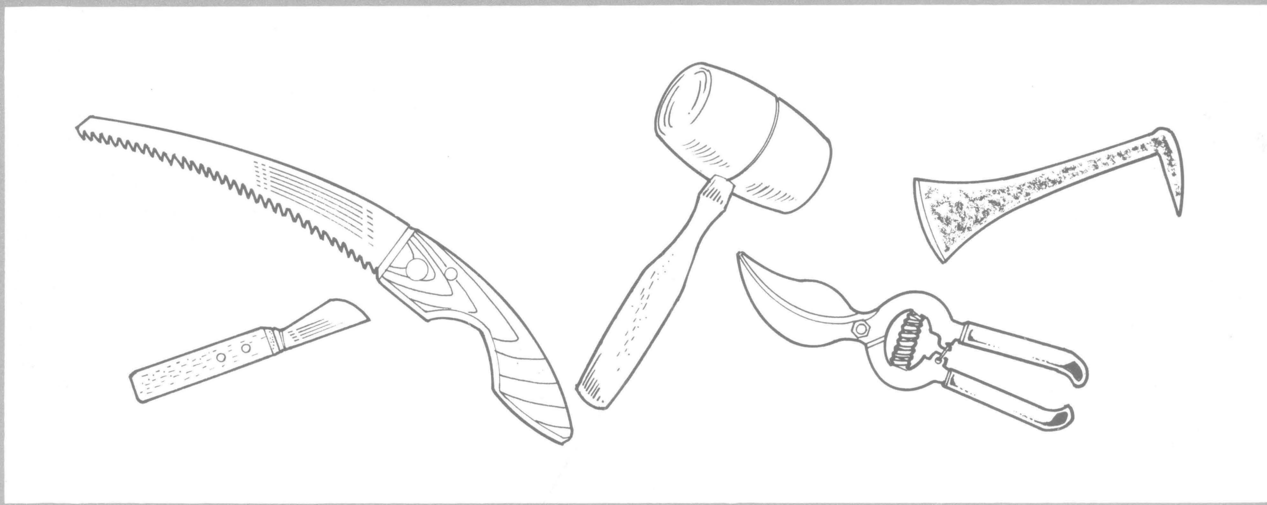
Making Grafting Wax At Home

For those who wish to prepare their own grafting waxes, the following formula and information are presented.

A standard **brush wax** consists of the following ingredients:

rosin	5 parts
beeswax	1 part
linseed oil	¼ part
lamp black or powdered charcoal	½ part

First, slowly melt the rosin, then add the beeswax. When both are completely melted add the linseed oil and stir. When mixed well, remove from the heat and add the lamp black or powdered charcoal a little at a time while stirring slowly. Continue stirring until it has a smooth consistency and is a uniform black color. The lamp black or charcoal will make the wax tougher and more pliable. Before use, brush wax must be melted to a consistency that can be brushed on easily, yet cool quickly and will not run.



PROPAGATION TECHNIQUES . . . These are the basis of the modern commercial tree fruit industry. Only through these techniques can trees of known growth and fruiting characteristics be reproduced and cultivars maintained. The ready availability and use of trees with known desirable characteristics offer the grower the opportunity of gaining the highest returns from his managerial skills.